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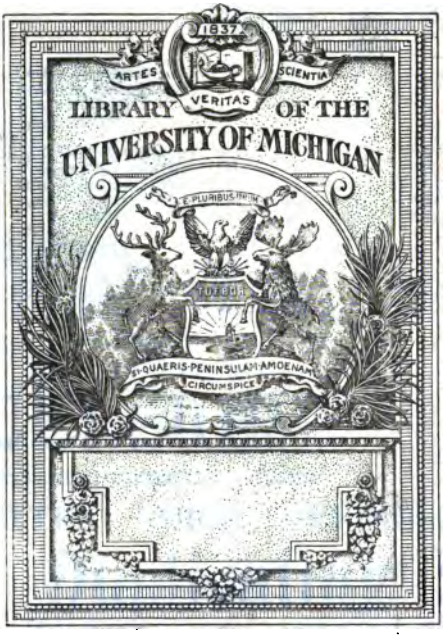

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Without aiming at giving an exhaustive account of the manner in which each separate business is conducted, the technical points in connection with each industry will receive as much attention as is necessary in order fully to elucidate the system of accounts advocated, while each volume will be the work of one who has made that particular class of accounts more or less a speciality. It is obvious, however, that to enable the necessary ground to be covered in the space available, it is incumbent to assume upon the part of the reader a certain knowledge of general bookkeeping. The extent of the knowledge assumed will vary according to the nature of the class of accounts considered. For example, in the volumes on "Bank Accounts" and "Shipping Accounts," a thorough acquaintance with ordinary double-entry bookeeping is not unnaturally assumed; but in the case, for instance, of "Auctioneers' Accounts," and other similar volumes, such explanations are included as will enable the ordinary intelligent reader fully to grasp the methods described, even although his knowledge of bookkeeping may be of an elementary description. These explanations are, doubtless, superfluous as far as accountants are concerned, but are necessary to make the volumes of value to the majority of those specially engaged in these particular industries.

To subscribers for the whole series it may be added that, when completed, it will form a most valuable and practically complete library, dealing, at the hands of specialists, with practically every class of accounts, and illustrating the application

of the theory of double-entry as described in general works on bookkeeping.

The first series (of twenty volumes) has already been completed, and particulars of the subjects dealt with will be found on p. i. A second series (particulars of which will be found on page ii.) is now in progress; it is expected that this second series will comprise about thirty volumes in all.

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EDITOR'S INTRODUCTORY NOTE.

THE organisation of a system of Cost Accounts in any established business depends mainly for its success on the relation of its methods to the lines on which the business has been developed.

A survey of the problems met with in various classes of business shows that lines of organisation, rather than similarity of products, provide the clearest basis for a system of Cost Accounts.

It follows, therefore, that we may classify all industries or undertakings in groups, according to their lines of organisation. By this means we are able to treat separately with the special problems and requirements of each group, and to indicate the methods which are specially applicable to any particular organisation of business.

The grouping adopted in this series is as follows :—

(1) MULTIPLE COSTS.—Applicable to undertakings where a number of products are involved bearing little or no apparent relation to each other in cost or selling price—such as Engineering Specialities, Cycles, Hosiery, Boots, Furniture, Agricultural Implements—in which standardisation in parts is carried to a high degree of specialisation in manufacturing.

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(3) SINGLE COSTS.—Applicable to Breweries, Collieries, Quarries, Mines, and businesses in which there is a natural unit of cost, as the barrel, the ton raised, &c. &c.

(4) PROCESS COSTS.—Applicable to Chemical Industries, Food Products, &c., in which conversion of material takes place, and there are principal and by-products—such as Tanners, Fellmongers.

(5) OPERATING COSTS.—As Railways, Tramways, Gas and Water Undertakings, Electricity, and similar industries.

It is to be noted, however, that there are instances of businesses which, from the special nature of their organisation, except themselves from their own group. The character of their production, and the degree of specialisation attained in the method of manufacture, constitute the only effective basis of decision as to which group they should be classified under.

The present volume deals with the fourth of these groups. The volumes on Multiple Costs, Terminal Costs, and Slngle Costs have already been issued. Operating Costs having been dealt with, more or less directly, in previous volumes of "The Accountants' Library" (*e.g.*, Vols. VII., XV., XIX., XXIX.), it is not considered necessary to devote a separate number to the subject.

INTRODUCTION.

IN the companion volumes treating with Cost Accounts the division between the several branches of this subject has been very strictly maintained, and the present volume will prove no exception.

In dealing with chemical processes, with a view to formulate a system of Cost Accounts which shall be accurate as regards the general accounts, and at the same time provide the details necessary for the assistance of the management and board of directors, it would appear essential that a complete knowledge of the operations involved should be attained, if a successful issue is to result.

The experience of the accountant, however, in dealing with all classes of accounts, and the instinctive recognition of the essentials for business success which is the result of his training and education, peculiarly qualify him for dealing with the complex problems which are to be met in Process Cost Accounting. The amount of special knowledge required to adapt and discriminate in instituting Cost Accounts for the chemical industries is not more than can be expected of him.

With a view to place the reader in a position to take a comprehensive view of the methods by which such a system may be formulated, the various stages of chemical processes, so far as

they affect results and their measurement, have been treated in the following pages.

It has been thought desirable, in the first place, to deal generally with the problems affecting measurements of solids and liquids, so far as the same are likely to be required for cost purposes; and while it is not intended to teach chemistry or chemical processes, the various technical data have been dealt with in as concise and simple form as possible, in order that the reader may be in a position to appreciate the incidence of these factors in compiling Cost Accounts, and to recognise the opportunities for leakage and waste which are likely to arise in that connection.

The treatment of this branch of Cost Accounts therefore follows three main divisions, in the first of which the various technical data are dealt with, and to which is appended a series of tables which will be useful in following out the various processes touched upon. In the second division illustrations are given of processes where the principal elements of all chemical processes are in operation—such as Moisture, Extraction, Concentration, Drying, of which the illustrations and examples of Forms of Works Returns will be found of special interest. In the third division the methods of obtaining the figures and results have been fully dealt with; while chapters on Coal and Power Charges, Standard Output, Stocks, Transportation of Materials, and other subjects of economic interest have been added, covering practically the whole of the problems to be met with in this branch of Cost Accounts.

It may be noted that as regards the *pro formâ* illustrations given, these forms, and the accompanying examples, are the result of actual experience; and while in some cases they fall short of theoretical perfection, they have been actually carried out in practice, and are not intended to represent more than a basis on which others may go further in development.

The subject is necessarily a wide one, embracing as it does a great variety of trades and products. It must be remembered, however, that all processes are somewhat identical, from the point of view of their expression in sterling. It may be found that all trades have actually a general basis of operating costs; Wages, Raw Material, Process Material, Coal and Power Charges are common to all, and only differ in degree. The treatment of these factors in the following pages, therefore, will serve as a general basis for adaptation, no matter what the special circumstances of the particular industry may be, so long as it falls under the description of industry to which this volume of Process Costs is applicable.

PROCESS COST ACCOUNTS.

DIVISION I.

TECHNICAL DATA OF PROCESSES.

CHAPTER I.

THE successful institution of a system of cost to processes involving the conversion of materials such as obtain in the chemical and allied industries demands considerable powers of conception, in addition to a wide knowledge of the various movements usually met with in this class of businesses.

The first essential step is the provision, in some more or less complete form, dependent on circumstances, of the scheme of the process, and it will possibly be found a difficult matter to obtain this in a sufficiently explanatory form to be of service. Even when obtained in full detail there is necessarily much that is obscure, and it is not easy to obtain that grasp of the operations which is essential to the drafting of a complete scheme.

In this and the following chapters, therefore, an attempt is made to bring out the various points which are likely to arise in connection with process accounting.

In the first place, the aim should be the localisation of the cost in the various stages at which records are possible. It may, and often will, be necessary to proceed backward step by step from the product to the raw material, in order to make sure of

the accuracy of the scheme. To this end the full dissection of the Sales Day Books into Products, the Purchases, and the Wages Books will afford the particulars of the three principal factors of prime cost, and this information should be analysed back into the various stages and earmarked to each particular stage of manufacture.

This information should then be charted and the constituent values of the products assessed and noted. The general expenses will require more elaboration, but had better be left at this stage and the prime cost elements treated by themselves.

The Coal and Power charges should be analysed out from the Wages, Purchases, and Stores, and grouped in one account.

We are then ready to deal with the technical side.

It will frequently be found that the reputation of a business depends largely on the adoption of some special form of process as applied to one particular stage of the product or products. It may be in the blending of the raw material, it may be in the special treatment of the raw material, or it may be in the special quality or description of the process material used in the manufacture. It will probably be found that, so far as the other parts of the process are concerned, the methods and process materials are common property.

It may also be found that the practical monopoly enjoyed by a firm is due to a special saving in cost of production as applied to one special stage of manufacture; as, for instance, the concentration of weak liquors in vacuo, explained hereafter, as against old-fashioned processes used by other manufacturers. Frequently the other portions of the manufacturing stages may be old-fashioned, extravagant, or wasteful, but in the absence of localisation of cost these extravagances are obscured by the special saving.

It is therefore the primary function of process accounting to secure for a system a thoroughly well-devised scheme, which will localise the actual cost conditions existing at the various stages, and which will thus render inestimable service in bringing up for consideration any disproportionate expense of process that exists. Not only is this essential from the view of cost, but also from the point of view of reform; given a system which reveals the blot, the thinking and organising power can grapple with the problem with the actual cost conditions, not estimates, in its hands.

The necessity for localisation of cost being granted, and its importance allowed, it will be evident that to apply the principles of accounting to this end needs a special knowledge if the results are to command the respect of those actually engaged in operating.

Throughout the whole of this series the reduction of generalities has been one of the principal objects to be borne in mind, and the questions involved in process cost methods form no exception to the general rule, and will also lend themselves to classification.

It may appear that the variations would be increased sevenfold in this section, and that no grouping would be of service in dealing with individual processes. A little consideration, however, of chemical and allied products reveals that these fall naturally under one of three great divisions, viz.:—

Processes in which the resultant products are solids.
do. do. liquids.
do. do. gases.

It will be found that in this grouping of their technical treatment the data of measurement and division of products, so far as process accounting is concerned, are practically identical in their incidence. Not only so, but the operations under these

heads are very similar in their relations to cost methods, and the special points affecting the accuracy of the Cost Accounts resemble each other in their groupings. It is not, however, intended to make this division of the book a treatise on chemistry, but rather to enable the reader to become "an intelligent client," and to place him in a position to appreciate the opportunities for leakage and error.

Processes.— **Table A 1.**

ILLUSTRATION OF GROUPING.

Solids	Starch
	Mustard
	Blacklead
	Leather
	Food Products
Liquids ..	Beer
	Dye Extracts
	Tanning Extracts
	Sulphuric and other Acids
	Peroxide of Hydrogen
Gases	Oxygen
	Sulphurous Acid

CHAPTER II.

RAW MATERIAL.

RAW material may be classed under two heads, "Wet" or "Dry," using these terms in their popular sense. The line of demarcation depends largely on the content of water carried by the substance, and "wet" materials would include skins for tanning.

Dry Raw Material,

whether as natural products, such as iron ores, pyrites, oxides, or as manufactured products in the state at which they arrive at the works of the manufacturer, possess a very wide content of moisture. The following Table A2 has been compiled from a variety of sources, and in some cases from actual tests made for this volume.

The figures given in the table are the usual maxima and minima, but these limits are very largely exceeded in individual instances. The fluctuations are undoubtedly serious, and affect the cost to a very considerable extent.

Table A 2.

RAW MATERIALS AND MOISTURES.

	Minimum	Maximum
Wheat Flour—English	14	18
Bran	10	12
Salt	6	8
Gum Arabic	15	17
Indigo	3	6
Oxalic Acid	24	28
Sugar Beets	75	89
Wheat	12	14
English Oats	11	13

RAW MATERIALS AND MOISTURES—*continued*.

	Minimum	Maximum
Maize	12 ..	14
Rice (without husks)	12 ..	13
Hops—Austrian	9 ..	11
Wool	18 ..	19
Silk	11 ..	12
Oak	33 ..	35
Wood—Beech	18 ..	20
Pine	38 ..	40
Willow	25 ..	27
Logwood	13 ..	15
Bauxite	10 ..	25
Clays	11 ..	13
Kaolin	10 ..	14
Grease and Fat	1½ ..	2
English Barley	12 ..	14
„ Slack	8 ..	10

The term "dry," used in a technical sense, means that a substance when subjected to a temperature of 212 degrees Farenheit loses nothing in weight. As will be seen from the figures shown in the foregoing table, there is an inevitable loss of weight in many conversions of material, carried out as they are at temperatures above the normal.

In many cases, when the initial process is that of steeping with acids or extracts, the effect of an excess of moisture is to reduce the efficiency of the process by dilution, and therefore to prejudicially affect the cost by reducing the resultant product in weight.

The value of the water is *nil*, and a material at £10 per ton, containing an excess of 5 per cent. over its standard, means a loss of 10s. per ton. Other instances will readily occur to the reader from his own experience. The questions involved in the moisture content will be found more or less continued throughout the whole of the process stages, and frequently it will be found that the actual percentage of moisture present in the finished product, in the raw material, and at the end of each stage of manufacture differ very considerably. These differences, especially in view of the fact that many businesses take half-finished products as their raw material, constitute a distinct

element of cost, reflecting, as they do, in additions to or decreased yield of products. In dealing, therefore, with localised cost stages this factor requires to be constantly borne in mind. The only safe and certain method is to carry through all calculations, if based on original weight, on the dry matter contained therein, or if on the finished product, then on the constituent value, and calculating all weights back to the actual dry initial weight.

There are few more deceptive bases of calculation than moisture averages of raw material. The very considerable fluctuation that exists in condition cannot always be judged. In one case under observation—a material in which 12 per cent. moisture was the recognised limit—it was found that, without exciting comment beyond the time taken to mature, this raw material was carrying a moisture content of at least 21 per cent. The alteration was due to changes of process on the part of the sellers, which, of course, the purchaser was not advised of. Changes of process occur perhaps more rapidly to-day than in any period of experience, and most probably this tendency will accelerate itself in the future, in view of the rapidity of process changes and developments.

A further consideration of moment is the factor of moisture in the finished product. As a general rule, the moisture content of the raw material has little or no relation to that of the finished product. In some cases the finished product may not be sold on a basis of constituent value. Take soap as an example, blacklead, starch, blue, and other examples which will readily occur to the reader. If we assume for a moment an output, say, of 1,000 tons per annum of a finished product carrying 10 per cent. moisture, an alteration of process which affects the physical properties so as to allow of 11 or 12 per cent. moisture content will have the effect of an increase of 10 to 20 tons in weight, and, say, at £25 per ton, a value of £250 to £500

increased price at a cost of nothing in process. Just as an increase in moisture will increase the profit, so a deficiency in the standard of moisture will have the opposite effect. In some cases the moisture content of the finished product requires to be diminished for process reasons, such as grinding, &c., below the normal, in which case the period during which the product is allowed to remain in stock afterwards has an appreciable effect on the actual weight sent out.

The following table gives examples of the moisture content of various finished products, which will illustrate this argument, and in this connection the saying that the art of the soapmaker consists in making water stand on end does not appear to be far from the truth.

Table A 3.

Description	Percentage of Moisture
Soap—White	30 to 35
Do. Mottled	45 ,, 50
Starch—Common	4 ,, 5
Do. Potato	14 ,, 15
Dextrine (according to source)	5 ,, 18
Glucose do.	14 ,, 19
Malt	5 ,, 8
Cottonseed Cake	13 ,, 15
Linseed Oilcake	10 ,, 12
Sugar—Demerara	3 ,, 4
Do. Beet	2 ,, 3
Do. Cane	1½ ,, 2
Molasses	20 ,, 27
Condensed Milk	24 ,, 26
Butter	7 ,, 14
Cheese (according to make)	24 ,, 37

The following table gives an illustration of the moisture content of the raw material and inter-process condition in the cost grouping No. 2 illustration:—

Raw Material	20 per cent.	on Original Weight.
Extraction A Department	4·6 ,,	Actual ,,
Maceration Department	31·0 ,,	,, ,,
Extraction B Department	40·5 ,,	,, ,,
M Department	25·3 ,,	,, ,,
Do.	12·4 ,,	,, ,,
Product No. 2	12·7 ,,	,, ,,
W Department	8·9 ,,	,, ,,
X Do.	11·3 ,,	,, ,,

Constituent Values.—

Other considerations affecting the purchase of raw material (solids) are the qualities represented by the valuable constituents contained therein.

In many cases material is purchased on a guaranteed analysis of its content of one, or may be two, constituents, and it is possible to buy more than one percentage in value. In other cases the constituent required may be contained in a slightly different form, as borax and boracic acid. In other cases the value of the raw material requires to be judged by its texture, colour, or other attribute, as in the case of mustard, corn for starch, barley for malting, and seeds for colour, &c

In connection with this it is to be borne in mind that very often the special constituent on the basis of which the purchase takes place is not actually present in that special form, but in a form which is equivalent. Pure alkali, for instance, is generally guaranteed as 58 per cent., or equal to 98 per cent. carbonate of soda. Caustic soda may be purchased in three different constituent values, as 60 to 62 per cent., 70 to 72 per cent., 76 to 77 per cent.; sulphate of ammonia, 24 per cent.; nitrate of soda, 96 per cent. pure; and the various acids in solution are generally sold on a definite constituent value. The margin of variation in these is usually small, the guaranteed percentage of constituent can usually be relied upon within ½ or 1 per cent., and, as regards costing purposes, it is usually only necessary to see that the proper percentage is clearly expressed, in order that no difficulties may arise in price.

Contracts are frequently entered into for one year, and other periods, which usually contain a clause stipulating for allowance to buyer in case of any variation being found in the percentage guaranteed.

The following table gives the names of the usual chemicals, with their scientific description:—

Alum	= Sulphate of Aluminium and Potassium
Aquafortis	= Nitric Acid
Baryta	= Barium Monoxide
Blue Vitriol	= Sulphate of Copper
Borax	= Sodium Borate
Caustic Potash	= Potassium Hydrate
Caustic Soda	= Sodium Hydrate
Salt	= Sodium Chloride
Copperas	= Sulphate of Iron
Glaubers Salt	= Sodium Sulphate
Lime	= Calcium Oxide
Magnesia	= Magnesium Oxide
Muriatic Acid	= Hydrochloric Acid
Oil of Vitriol	= Sulphuric Acid
B.O.V.	= Ditto
Pearl Ash	= Potassium Carbonate
Plaster of Paris	= Calcium Sulphate
Sal Ammoniac	= Ammonium Chloride
Saltpetre	= Potassium Nitrate
Soda	= Sodium Carbonate
Spirits of Salts	= Hydrochloric Acid
Sugar of Lead	= Lead Acetate
Vinegar	= Acetic Acid
White Lead	= Lead Carbonate
Prussiate of Potash	= Potassium Ferrocyanide

Space will not permit of a detailed description of the many uses for which these chemicals are purchased in processes. A great number are used in connection with bleaching processes and decolorising of raw material. It will possibly be found difficult to obtain specific information on this point without appearing unduly inquisitive, but a reference to any standard work on chemistry should disclose sufficient information for the purpose of checking the accuracy of the data supplied and its bearing on the cost system and method.

Table A 4.

SHOWING CHEMICAL SUBSTANCES AND CONSTITUENT VALUES.

Magnesia, Hydrate of	=	60% Magnesia.
Sulphur or Brimstone	=	99%.
Sulphate of Copper	=	98 to 99%.
Potash, Carbonate of	=	75 to 99% Potash K_2O.
Sulphate of Ammonia	=	24%.
Nitrate of Soda	=	96%.
Linseed Oilcake	=	97% and 95% Pure.

CHAPTER III.

MEASUREMENT OF SOLIDS.

THE measurement of raw material inwards in the great majority of instances is by weight, but in isolated cases, such as the tanning and allied industries, it may be by count and the weight may express quality.

The ascertainment of the initial weight involves no special difficulties apart from the questions of moisture and constituent value, both of which have been previously dealt with. After passing into manufacture the recording of weight will often be a matter of considerable difficulty, and for the purpose of setting up a system of cost the particulars of weight transferred from one department to another is a matter which will doubtless only be obtained by the exercise of some ingenuity and determination. So much, of course, depends on the particular method of conveyance adopted, the arrangement and relation of the departments to each other, that generalising is out of the question.

There are a number of points, however, which are common to all processes dealing with solids, and opportunities for leakage in these are practically identical.

Bulk.—

When any considerable quantity of material is dealt with it will generally be possible, in the first place, to arrive at an approximate calculation of the weight by taking the bulk capacity of the container, be it vat, tramway tub, or other vessel which may be a receptacle, or which may be used as a conveyer. The extensive use now made of automatic weighing

machines renders it possible to obtain exact and accurate records which were not possible formerly, and whenever these can be installed they afford a valuable check for costing purposes.

When these facilities are not available the number of tubs or wagons is usually taken as a basis of calculation, a test of the weight being made at short intervals. Provided that the basis of the average is sufficiently broad, this may work out approximately correct, especially if the records obtained can be checked in some way by the operating of the succeeding process. There are, however, several considerations to be borne in mind in the acceptance of this basis for cost methods. In the first place, the average should be a cumulative one, taken not only on a sufficient number of individual tests, but also at various periods of the year. In working on this basis the average should be continually revised and the variations noted weekly, and in some cases temperature and climatic influences may have a considerable influence on the result in taking bulk for weight. In other cases the grist will play an important part. Where raw material is ground, or "nutted," the condition of the grinding machinery will make a considerable difference in the grist, and the grist will cause some considerable variation in the bulk, and give an apparent increased yield. Changes in process and improvements in machinery are of frequent occurrence, and a systematic periodical test of the average accepted must be insisted upon, if this basis of measurement is to produce satisfactory results.

Not only so, but where possible it should be so arranged that the actual weight inwards and outwards should be compared at short periods.

The adoption of an estimate, a course which may represent the only available means of calculation, can only be justified by the care and attention paid to its verification from other sources. We have to consider that, even in the certified Balance Sheet of

an undertaking, some of the items—such as Stock, Plant, Book Debts, and other assets, and possibly some liabilities—are in the last resort dependent on estimates, and it is only the care and attention paid to their bases which can justify the certification of profits as actually earned. Estimates in inter-process measurement therefore stand on an identical basis, with the further security that they at least are capable of exact demonstration at some stage or other in their progress through the manufacturing departments.

The following table gives the weight per cubic foot of some ordinary materials, illustrative of the point of view of bulk capacity, as a basis for weight calculation:—

Table A 5.

WEIGHT PER CUBIC FOOT OF THE FOLLOWING MATERIALS.

Chalk	.. ..	143 lbs.	per cubic foot.
Clay	.. ..	125 ,,	,,
Coal	.. ..	82 ,,	,,
Coke	.. ..	50 ,,	,,
Sand	.. ..	120 ,,	,,
Shingle	.. ..	90 ,,	,,

Vats, Tanks, and other Containers.—

In estimating the average quantity of any solids which will be contained in any given vessel, some allowance will generally require to be made for differences in packing. The provision of a box containing exactly one cubic yard in capacity is a convenient method of testing this point, but it is frequently found possible to obtain a variation of one-half to one hundredweight to the yard in different tests with identical material in this method, a variation which depends entirely on the amount of "packing" the material receives in being filled. It is advisable to obtain the record, if possible, without the knowledge of the workmen engaged in filling, as by this means no special attention is given, and the record thus obtained will probably be a more representative one than otherwise. Not only so, but the probability of the filling being checked will also act as a

deterrent on carelessness. In cases where the record required is that of a spherical or circular vessel, filled through a manhole or other aperture, some allowance will require to be made from the cubic capacity. In one case under the writer's notice there was a variation from 7 to 8 cwts. in the filling of one vessel under these conditions when the same was tested with identical material.

In some cases such as these it may appear desirable to pass the weight record as too approximate for any basis of cost. The difficulty, however, lies in the variations which may occur in yield due to other causes, either to the efficiency of operating or the quality of the material. It is a safe rule that where the records are subject to fluctuation from other causes the chances of variation in weight should, if possible, by any means be eliminated from the equation.

It must be borne in mind that, even as an approximate check, the inwards raw material, the by-products, the conveying containers, and the receptacles filled should afford some basis of verification. It would not, in the absence of direct fraud, be expected that a mistake in any one of these should be covered by an identical mistake made under other dissimilar conditions of operating and in a compensating direction. Experience will readily afford a clue to the point at which any discrepancy occurred.

Condition.—

In some stages the raw material may, by reason of water absorption or from its reduction to a liquid or paste, prove incapable of measurement by weight, while if not carried to this degree the quantity of moisture present may afford some considerable difficulty in the determination of the weight, either as such or in measurement by bulk. It may also be difficult to obtain an average sample for analysis, by which the quantity of dry matter may be ascertained. This is, in the first place,

the business of the process chemist, but the matter is sometimes complicated by alterations in bulk through water absorption rendering the container measurement of no value. In all these cases the application of an average must be justified by the extension of the basis on which it is taken. In the case of water absorption the period of test will doubtless be affected by atmospheric conditions, and these may necessitate the preparation of an average which may vary according to the season of the year. In all process accounting the capacity for taking pains in ensuring that the details are accurately ascertained will mark the qualifications of the person responsible for the system.

The increase in weight by absorption will be found to vary with the grist of the material. For instance, coke in one inch grist will absorb an altogether different quantity of moisture to coke dust, as in the latter case the percolation of the water is hindered by the closeness of the packing, and the centre may, unless agitated, be quite dry. Each separate grist will require a different test, and in this connection the remarks on grist in this chapter require to be carried in mind.

Malting.—

In this case we have several illustrations typical of processes. The malting may be divided into four stages—(1) Steeping, (2) Couching, (3) Flooring, and (4) Drying, and we may note, in the first place, that English barley, as per Table A2, contains, say, 13 per cent. as a mean average of moisture. In the first stage of steeping the absorption of water equals 45 to 50 per cent. in weight, and the bulk has increased 22 to 24 per cent., against a loss of 2 per cent. in weight partly carried off in the water. In the third stage the actual loss in weight is equivalent to 10 per cent. on the original weight of the grain. Finally, the malt is dried, and the finished product will contain 5 to 7 per cent. of moisture.

Original Weight.—

It will be seen, therefore, that in any attempt to localise this or other like cost the relation of the finished product to the original weight must be ascertained and worked back on its relation to the dry matter at all stages.

Wheat.—

In the comparison of the yield of English and foreign wheats for milling, there is an advantage in favour of English wheat by reason of its freedom from dirt. This is offset, however, by the fact that in washing wheat the percentage of dirt present in the foreign wheat is counterbalanced by its dryness allowing of a greater water absorption and consequent increase in weight.

ILLUSTRATION OF LOCALISED YIELD AND COMPARISON WITH ORIGINAL WEIGHT.

	Per cent.
Sortings	3·00
No. 1 Product	4·66
M Product A	8·15
Do. B	40·91
No. 2 Product	10·87
	67·59
Moisture	24·16
Loss in separated matter	8·25
	100·00

Where the raw materials are ground or pulverised in some form or other, especially if fine powder is produced, there will be some leakage in dust, or possibly tailings, to take into consideration. In other cases there may be residues which are treated, whether of value or otherwise, as by-products. The various forms of milling machinery are numerous, but usually in such cases definite guarantees are given by the makers of the machines, and often the percentages of the different grists obtained from various substances may be found in their catalogues or are obtainable from them.

The records of results in these modifications of raw material are usually obtainable by reason of the necessity for weights in mixing, and therefore the checking of the results is generally

possible. It will in all cases be desirable to express in the costing the leakage as a debit item, rather than allow its incidence to affect the account by inference in the balance.

In many cases the use of automatic weighing machines renders the records reliable and also readily obtainable by means of self-registering apparatus attached thereto.

Other modifications of raw material occur as either initial or secondary processes in mixture with other ingredients. In the majority of instances these are made by means of weight measurement, and cause no difficulty in the aggregation of bulk or weight, but frequently there may be residues which are not necessarily stable in results. The disposal of these residues will provide the necessary means of valuation in the Cost Account, but, as residues are often found valuable, it is desirable that all items, whether of value or otherwise, should appear in the account, as their measurement will be required in contra to balance.

The point at which Costing Accounts should break depends on a variety of circumstances, wages, by-products, and possibility of measurement being the governing factors. It may be necessary for wages cost to separate stages of manufacture in which no contra can be obtained, or in which the condition of the product does not lend itself to any form of measurement. Two examples of this will be found in Cost Group No. 2 in the maceration and crystallisation processes, in which the cost is ascertained, but in which the yield and credit is not ascertainable.

In many instances, especially at the initiation of any system of process accounting, this method may be adopted with advantage as a preliminary to a later absolute determination of the cost. This has been found to work out well in actual practice, as the value of the information thus obtained does tend to encourage the further separation and record of actual results in yield. Compare the Cost Summary and the criticisms thereon in Cost Group 1 and 2 on this point.

In some cases, which are, however, fast disappearing before better and more scientific handling of products, it may be necessary to accumulate in stock products in an unfinished state. This may be rendered necessary by reason of wide fluctuations in the inwards flow of material, or seasonal demand. In such cases the method of measurement applied at the annual stocktaking will form the basis of computation for shorter periods, and although this may not apply in all cases the hints on measurement before given should provide some indication of the way in which this should be grappled with. In one undertaking, of which the writer has had some experience, no stoppage for stocktaking takes place; on account of the difficulty of identification a line is drawn, and the products finally work themselves out, and are priced less the estimated cost of finishing from their various stages.

The following table, given by Mr. Davis in his work on Chemical Engineering, may prove of assistance for stocktaking purposes:—

Table A 6.

STORAGE CAPACITY REQUIRED FOR VARIOUS CHEMICAL SUBSTANCES.

	Lbs. per cubic foot.	Cubic feet per ton.
Alkali Waste	80	28
Barium Sulphate	150	15
Bicarbonate of Soda	60	37
Black Ash	60	37
Bleaching Powder	50	45
Burned Pyrites	95	24
Caustic Soda	126	18
Clay, wet	103	22
Coke	30	75
Crinkled Glass	32	70
Flints	100	23
Furnace Cinders	45	50
Lime in lumps	62	35
Do., sieved	35	64
Limestone, crushed	87	26
Round Coal	50	45
Salt	53	42
Sand	100	23
Slack	46	50
Soda Ash	75	30
Soda Crystals	64	35
Sulphate Ammonia	70	32

CHAPTER IV.

MEASUREMENT OF LIQUIDS.

THE problems affecting the measurement of liquids are somewhat simpler than in the case of solids, but usually processes dealing with liquids combine with solids either by way of extract or solution.

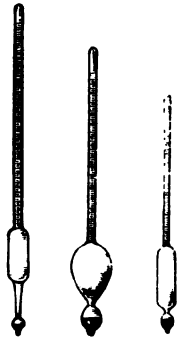
Necessarily liquids require a container, whether as a receptacle or conveyer, and we have therefore the data of measurement within more strictly defined limits than in the case of solids.

The cubical contents of receptacles, and the volume of given diameters of orifices, lend themselves to ready determination of results, and the computation of the quantitative measurement can be obtained from existing or from readily provided tables.

Practically all processes dealing with liquids as such require, however, the statement of measurement to be taken both in quantitative and qualitative expression of value, and the latter is usually derived from the comparison of the specific gravity of the liquid with water at 60 degrees Farenheit.

There are various instruments for ascertaining the specific gravity, all more or less dependent on the depth to which a loaded bulb of glass, to which a stem containing a scale is attached, will sink in a sample of the liquid. This sample is

usually taken in a glass jar of about 10 to 12 inches in height and 1½ inches in diameter, as per illustration.



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The Principal Instruments of Measurement of Quality are—

TWADDELL HYDROMETER.—Used principally in Great Britain. For convenience these are divided into ranges or sets, as, for instance, 0 to 24, 24 to 48, 50 to 75, and so on.

BARKTOMETER.—Used principally in Great Britain, originally for the purpose of obtaining the specific gravity of the liquor in the pits in tanning, but now extended to a number of other industries.

BEAUME LIGHT LIQUIDS, BEAUME HEAVY LIQUIDS.—Used on the Continent and in the United States of America.

These instruments differ principally in the scales attached to the stem and the weight inserted in the bulb. They are readily comparable, and data will be found for their reconciliation in most chemical table books.

The application of the specific gravity test to liquids as indicating the value of the product requires one very important qualification—viz., that of temperature.

The temperature in Great Britain is usually taken on the basis of the Fahrenheit thermometer, but there are in addition that of Centigrade and also Reamur.

The following table gives the comparison of these in an abbreviated form.

Table A 8.

Fahrenheit. Degrees.		Centigrade. Degrees.		Reamur. Degrees.
212	..	100	..	80·0
200	..	93·3	..	74·7
150	..	65·6	..	52·4
112	..	44·4	..	35·6
110	..	43·3	..	34·7
110	..	37·8	..	25·8
90	..	32·2	..	21·3
80	..	26·7	..	16·9
70	..	21·1	..	12·4
60	..	15·6	..	0·0
32	..	0·0		

In practice the weight of a cubic foot of water is taken as equal to 1,000 ounces.

For the purpose of costing, especially in continuous or partly continuous processes, it is often difficult to obtain the measurements of the liquids at rest, as they may not be at rest at any available time for measurement. In such cases the measurement may depend on the time taken to pump the liquid, or, as in the case of sulphuric acid, the number of "eggs" of the liquid forced up to a tower, or, otherwise, the quantity of liquid flowing through pipes or conduit.

In the case of water this may be ascertained by a water meter, but often the liquids required to be measured do not allow of their being passed through a meter. In these cases where

pressure is absent the use of the measuring box may be possible, and a common example of this will be found in the apparatus used for flushing lavatories, &c.

In the case of hot water from condensing tanks, outflow pipes can be arranged so as to run full, and more than one of these can be employed. The gallons which a 1-inch pipe three inches long will pass in an hour is approximately 200 gallons, while a 2-inch pipe six inches long will pass 1,100 gallons, and a 3-inch pipe nine inches long 3,000 gallons. Water meters have been applied for beer, petroleum, and other liquids, and if care is used to protect the apparatus, and short periods of use, alternated with proper cleaning, their use may be greatly extended in cases where the measurement of the liquid passing is a matter of moment, either in regard to cost or to the efficiency of the process.

CHAPTER V.

GASES.

THE principal factors to be met with in processes connected with the production of gas, in so far as costing is concerned, is the measurement of the product residues and solutions.

The temperature of the gas affects vitally the velocity with which the gas will pass through a given diameter of pipe. When cool enough it may be measured by a gas meter. Most tables and formulæ for this are based on the flow of air through a pipe, but when dealing with air or gas under pressure the length of the pipe plays an important part in the quantity. For instance, the volume of air passing through a 2-inch pipe one yard long under a pressure equal to one inch of water is approximately 7,500 cubic feet per hour, while if the pipe is lengthened to four yards only about half the volume will be discharged.

There are special instruments for measuring the flow of air and gases, known as "Anemometers."

In addition to the bulk measurement, the quality is ascertained by sampling and analysis.

In the case of sulphuric acid manufacture, the quantity of nitro compounds present in the gas is thus obtained, and the quantity of sulphurous acid.

In the case of the manufacture of sulphurous acid where this is produced in solution, the gases are passed into wooden or lead containers or vats, and the quantity of sulphurous acid produced may be obtained by the specific gravity of the solution. The same principle is adopted in many other cases.

In chemical works the movements of gases forms a very considerable part of the work, and the appliances by which this is accomplished vary generally with the pressure at which the movement is required to be made. In some cases the gas is moved by suction induced by a blower or fan. The pressure in the case of gases is generally estimated on the "inches of water." An element of cost in this respect is the horse-power required to drive the fan, while the revolutions provide a ready means of measurement.

Generally speaking, the mechanism by which the gas is moved will provide the means of measurement, given the time during which the same is in operation, and where this is not obtainable, as in the case of steam aspirators, &c., the volume or quantity can be obtained from the original charge, less the residues.

Residues.—

In the case of sulphuric acid manufacture, the residues are of considerable value, and the percentage of sulphur remaining is a fair test of the efficiency of the combustion which has taken place. An increase in the percentage of sulphur remaining is usually equivalent to a reduction in the price obtainable for the residues.

Sulphurous Acids.—

Large quantities of sulphurous acid are used in chemical industries for bleaching purposes, and many firms make a speciality of this acid, sold either in solution or in steel cylinders containing the compressed gas.

Where required in large quantities, however, it is generally produced by burning brimstone or sulphur in a closed oven, through which a large current of air is passed by means of a blower, fan, or air compressor.

In this case the gas is passed into large wooden vats containing cold water, and the water is generally impregnated with the

gas until the specific gravity of the solution becomes apparent. For instance, 3,000 gallons of water, into which the gas from 90 pounds of sulphur has been aspirated, should reach a specific gravity of three to four Barktometer, and the efficiency of this can be readily demonstrated by sampling at various heights of the container so as to obtain an average sample.

There is very considerable opportunity for leakage in bleaching with sulphurous acid in cost of process, by reason of the quantity of sulphur remaining unused in the bath after application. In one instance the quantity of effective power remaining was two-fifths of the original, while when the original quantity was reduced by one-third the loss was reduced from two-fifths to one-third; but, on the other hand, the actual effective power was also reduced below what was required for normal application.

CHAPTER VI.

LIQUID PROCESSES.

Concentration.—

THE concentration of liquids is common to most processes and is carried on by a variety of methods and plant.

There are, however, two major divisions of concentration which separate themselves—viz., Concentration under Atmospheric Pressure and Concentration in Vacuo.

The first method is comparatively simple, and consists in the evaporation of the water from the substance by means of direct heat applied either by fire or steam. This requires no explanation. Practically all liquid extractions are made by means of water, and the solution obtained is known as weak liquors; in brewing, for instance, all water to be used for extractive purposes is usually spoken of as liquor. It is usually requisite for the purpose of economic extraction to use an excess of water to obtain the extract required, and once this is obtained the mixture requires the excess of water to be driven off.

The methods adopted for extraction depend on the nature of the liquid and the resultant product. In some cases, as sugar, the liquid extract, or syrup, is concentrated, or the water removed until the crystals are produced, practically evaporation is continued until all excess water is removed.

Water does not boil under a temperature of 212 degrees Fahr., but in many cases this heat would seriously deteriorate

the product, either in quality or in colour. Hence evaporation in vacuo is adopted, and is being increasingly applied, both with considerably increased economy as regards cost, and also with beneficial effects on the quality of the products.

In evaporation or concentration in vacuo an air pump is employed to remove the air in an air-tight vessel, in which the extract is placed, and which is kept working during the period in which evaporation is continued. In consequence the extract will boil when a vacuum of 20 to 25 inches is obtained on the vacuum gauge (similar in all respects to a steam gauge) at a temperature of 110 degrees to 115 degrees Fahrenheit. The quantity of steam required to boil the extract is reduced considerably by this method, and steam is generally applied by means of steam pipes arranged in coils at the bottom of the vessel. The air pump works in conjunction with a water supply which condenses the steam and vapour coming from the vessel. The vessels are known generally as vacuum pans, but there are other classes of vessels in which the liquor is sprayed through a series of tubes, and is rapidly evaporated while passing through the tubes round which the steam is being circulated.

The opportunities for leakage in vacuum apparatus are principally concerned with leaky or worn-out tubes or joints in the steam coils, or owing to carelessness or inattention in working. In the case of many liquors which are concentrated the ebullition is considerably increased and many liquors in evaporation froth very much. It is consequently very easy for the froth to rise to such a height as to be drawn away with the vapour and steam, and in consequence the bulk is reduced and a loss takes place in the quantity of the product produced.

In arranging for costing where evaporation takes place by means of vacuum apparatus, the measurement of the weak liquors should be taken, and the measurement of the

concentrated liquor, and the specific gravity before and after evaporation noted. It is possible hy this means to provide a ready means of check upon the efficiency with which this stage of the process is carried out.

The steam required to work a vacuum apparatus is generally exhaust steam from the engines, the difference of 100 degrees at which water will boil under vacuo rendering the temperature of exhaust steam sufficient for that purpose. There are many evaporators at work now, in which the liquor is passed through three vessels, the steam and vapour from the first passing into the tubes of the second to do useful work, and from the second to the tubes of the third, a difference in the vaccum being maintained so as to allow of the liquor passing from one vessel to the other.

We have seen in the chapter on Coal and Steam Power that 6 lbs. of water is a usual evaporation for 1 lb. of coal in a steam boiler of modern efficiency. In those apparatus where three or more vessels are coupled together into one apparatus, the efficiency is increased to nearly four times, and 21 to 24 lbs. of water are evaporated by 1 lb. of coal in an efficient and well-arranged multiple effect vacuum apparatus.

The following tables, A9, A10, A11, and A12, show methods of obtaining results in concentration processes. The first two tables are based on single effect vacuum pan workings with copper coils, and are fully explanatory. Table A10 completes and carries out Table 9, giving the resultant yield in average weight of product. Tables A11 and A12 show the working of a Yar Yan evaporator, consisting of three tubular vessels, in which the weak liquor (feed liquors), as extracted, starting at one end at 9 Tw., is concentrated in passing through the tubes, and comes out at the other end of the apparatus at 24 Tw. The principal difference between the two kinds of apparatus is that

in the vacuum pan the extract is all completed at one operation, in the Yar Yan and similar apparatus the concentrated liquor is being produced all the time in small quantities. The tests are three in number to each operation, the first test being made while the apparatus is being gradually raised to its proper point of efficiency in working. In the ordinary course these are carried to the credit of Concentration Account and debit of Drying Account, and the averages are made cumulative by adjusting any differences in these two accounts on the finished product.

Table A 9.—B.G.L. Particulars.

WEEKLY SUMMARY OF CONCENTRATION

Shift	No.	No. of Drs.	Drawings	Pan No.	Vat No.	Inches	Bk.
February 26th—day	362	3	3.10 p.m.; and 14 inches from No. Vat	1	3 5 7	18 15 14	20 19 15
„ 27th— „	363	3	3.2 a.m.; and 14 inches from No. 4 Vat	2	3 5 7	19 16 17	27 30 25
„ 27th— „	364	3	3.6 a.m.	1	3 5 7	18 16 15	20 22 24
„ 27th—night ..	365	6	3.10 a.m. .. .. .. 3.2 p.m.	1—2	3 5 7	38 31 32	35 33 34
„ 28th—day	366	6	3.6 p.m. .. .. .. 3.10 p.m.	1—2	3 5 7	38 34 32	34 34 35
„ 28th— „	367	6	3.2 a.m. .. .. .. 3.6 a.m.	1—2	2 4 6	39 32 34	38 36 38
„ 28th—night.. ..	368	6	3.10 a.m. .. .. .. 3.2 p.m.	1—2	3 5 7	40 32 32	38 36 40
March 1—day..	369	7	3.6 p.m. .. .. .. 2.10 p.m. .. .. .. 2.2 a.m.	1—2	2 4 6	60 47 20	38 40 28
„ 1—night	370	6	2.6 a.m. .. .. .. 2.10 a.m. .. .. .. 2.2 p.m.	1—2	3 5	60 45	40 40
„ 2—day	371	6	2.6 p.m. .. .. .. 2.10 p.m. .. .. .. 2.2 a.m.	1—2	2 4	60 48	40 40
„ 2—night	372	6	2.6 a.m. .. .. .. 2.10 a.m. .. .. .. 2.2 p.m.	1—2	3 5	60 50	45 45
		58					

WORKING. Week ending March 4th 1905.

Time Started	Time Tested	Tw.	Time Tested	Tw.	Time Finished	Tw.	Time Taken	Table Vat	Inches
		13		17		19		W	19
10 p.m.	12 p.m.	140	2 a.m.	134	4 a.m.	128	6 hours ..	X	19
		14		17½		19		Y	22
2 a.m.	4 a.m.	140	6 a.m.	134	8.30 a.m.	128	6½ " ..	Z	22
		13		17		19			
6 a.m.	8 a.m.	140	10 a.m.	134	12 a.m.	128	6 " ..	W	22
		13		17		19		Y	30
4 p.m.	7 p.m.	140	9 p.m.	136	11 p.m.	128	7 " ..	Z	29
		14		17		19		W	30
12 p.m.	2 a.m.	140	4 a.m.	136	6 a.m.	128	6 " ..	X	30
		13		17		19		Y	30
6.30 a.m.	9 a.m.	140	11 a.m.	134	1 p.m.	128	6½ " ..	Z	30
		13½		17		19		X	38
6 p.m.	9 p.m.	140	11 p.m.	136	1 a.m.	130	7 " ..	Z	26
		13⅛		17		19		Y	35
3 a.m.	7 a.m.	140	9 a.m.	134	11 a.m.	128	8 " ..	Z	35
		13½		17		19		W	36
6 p.m.	9 p.m.	140	11 p.m.	136	12.40 a.m.	130	6 hrs. 40 mins.	Z	27
		14		17½		19		Y	35
3 a.m.	6 a.m.	140	8 a.m.	136	10.30 a.m.	130	7½ hours ..	X	30
		13		17		19		Y	28
6 p.m.	9 p.m.	140	11 p.m.	136	1 a.m.	128	7 " ..	Z	40

Table A 10.

SUMMARY OF WEEK'S OPERATING CONCENTRATION PROCESS, SHOWING YIELD,

Week ending.....

Day	No.	Vat No.	Gallons per Inch	Inches	Gallons	Bark	Total Gallons	Table Vat	Inches
Sunday	169	3	21·93	18	394·74	18	7,105·32		
"	"	5	27·52	30	825·60	40	37,024·00		
"	"	7	27·52	15	412·80	16	6,604·80	WX	720
"	170	6	27·52	42	1,155·84	15	17,335·60	X	252
Monday	171	2	21·93	58	1,271·94	35	44,517·90		
"	"	5	27·52	32	935·68	26	24,327·68		
"	"	7	27·52	30	825·60	26	21,465·60	WX	864
Tuesday	172	3	21·93	40	877·20	23	20,175·60		
"	"	5	27·52	32	880·64	24	21,133·36		
"	"	7	27·52	32	880·64	28	24,657·92	WX	954
Wednesday	173	3	21·93	40	877·20	28	24,561·60		
"	"	5	27·52	32	880·64	26	23,396·64		
"	"	7	27·52	32	880·64	30	26,419·20		
"	"	1	21·19	56	1,186·54	85	100,855·90	WYZ	1,494
Wednesday	174	2	21·93	60	1,315·80	30	39,474·00		
"	"	4	27·52	50	1,376·00	28	38,528·00	XYZ	1,440
"	175	5	27·52	50	1,376·00	35	48,160·00		
"	"	6	27·52	48	1,320·96	32	42,270·72	WXY	1,476
Thursday	176	3	21·93	60	1,315·80	30	40,789·80		
"	"	7	27·52	46	1,265·92	32	40,509·44	WX	1,440
"	177	2	21·93	60	1,315·80	32	42,105·60		
"	"	4	27·52	47	1,293·44	34	43,976·96	Z	1,512
Friday	178	2	21·93	36	789·48	18	14,201·64	6"	
"	"	4	27·52	30	825·60	16	13,209·60	4"	540
"	179	5	27·52	60	1,651·20	30	49,536·00		
"	"	5	27·52	60	1,651·20	28	46,233·60	VZ	846
						36	858,576·48	18 galls. per inch ..	11,538
								621 galls. per ton..	18·57 tons
						Average	23,849·34 gallons		

SPECIMEN SHEETS FROM YAR YAN EVAPORATOR. CONCENTRATING WEAK LIQUORS.

Table A 11. DAILY RECORD.

Date	Time	Boiler Pressure in lbs.	Pressure in Receiver	Pressure in Shell of 1st effect	Vacuum in Separators		Feed Liquor		Concentrated Liquor		Temp. of Injection Water	Temp. of discharge from Vacuum Pump	Temp. of Drip Water	Number Coolers run off	
					1st	2nd	Strength	Temp.	Strength	Temp.					
June 27	6.35	45	12	1	11	26	9	147	24	112	67	86	169	No. 5	Tw. 9
"	7.35	40	13	2	10	25	8	158	24	113	67	88	172	Straight	Through Tw. 24.
"	8.35	43	13	2	10	25	8	162	24	113	67	89	175		Finish 8.40
"	8.45	45	13	2	10	25	7½	170	24	115	67	90	178	No. 6	Tw. 7½
"	9.45	41	13	2	10	25	8	165	24	115	67	90	177	Straight	Through Tw. 24
"	10.45	42	13	2	10	25	8	163	24	115	67	92	177		Finish 11.0
"	11.5	44	13	2	10	25	8	157	24	114	67	91	176	No. 4	Tw. 8
"	12.5	45	13	2	10	25	8	161	24	114	67	91	177	Straight	Through Tw. 24
"	1.5	42	13	2	10	25	8	164	24	115	67	90	177		
"	2.5	41	13	2	10	25	8	166	24	115	67	90	176		Finish 2.15

REMARKS.

Table A 12. DAILY RECORD.

Date	Time	Boiler Pressure in lbs.	Pressure in Receiver	Pressure in Shell of 1st effect	Vacuum in Separators		Feed Liquor		Concentrated Liquor		Temp. of Injection Water	Temp. of discharge from Vacuum Pump	Temp. of Drip Water	Number Coolers run off	
					1st	2nd	Strength	Temp.	Strength	Temp.					
June 18	6.30	45	13	2	12	26	8	150	23	113	66	84	170	No. 5 Run	Tank, Tw. 8
"	7.30	43	13	2	10	26	8	155	23	114	66	85	171		Straight Through
"	8.30	45	13	2	10	26	8	157	23	114	66	85	171		Finish 9.0 | Tw. 2
"	9.5	45	13	2	9	26	7½	165	23	115	66	88	175	No. 6 Straight	Tw. 7½
"	10.5	42	13	2	9	26	7½	168	23	115	66	89	175		Through, Tw. 23
"	11.5	44	13	2	9	26	8	160	23	114	66	89	175		Finish 11.35
"	11.40	45	13	2	9	26	7	170	23	115	66	90	179	No. 3 Straight	Tw. 7
"	12.40	41	13	2	9	26	7½	162	23	115	66	90	180		Through, Tw. 23
"	1.40	45	13	2	9	26	7½	160	22	115	66	90	180		
"	2.40	43	13	2	9	26	7½	163	23	115	66	91	183		Finish 2.45

REMARKS,

Precipitation and Clarification.—

In processes dealing with liquids a precipitation is often required. This may be effected by mechanical or chemical means, and involves the "throwing down" of suspended matters in the solution by means of their entanglement with a heavier substance. From the very earliest times alum has been used by the Chinese and the Indians to clear waters rendered turbid by suspended matters. The purification of water by Clark's method is an illustration of precipitation, and will also serve to illustrate the point of interest in process accounting.

In the case in point lime and caustic soda are added to the water to neutralise the excessive hardness, and actually produced the required results. This was assisted by agitating the water, in consequence of which the carbonates, &c., fell to the bottom in a heavy sludge. This was agitated, and when it had settled the clear water was decanted by a floating arm, the end of which was carried by a float resting on the water and allowing the end of the pipe to lie a few inches below the surface. The water, however, contained a large quantity of magnesia, and this involved a very flocculent sludge, with the result that the quantity of sludge necessary to leave in the bottom of the tank constituted a large percentage of the total water treated.

This added to the cost by reducing the net quantity of water rendered available and increased the cost of chemicals per gallon.

The weekly quantity treated was, say, 100,000 gallons, out of which, owing to the small quantity treated in one operation, 25,000 gallons was wasted in residues.

In the precipitation process, therefore, the interest to the cost accountant lies in the recording of the total quantity treated as compared with the net result, and this requires to be obtained as a percentage, in order that the net result of the process may

be shown. In solutions other than water it will frequently occur in precipitation processes that the residue may be pumped or gravitated back either to the previous process or to the extraction process from which the original liquor originated, and it will frequently be found from one cause or another, especially from careless working, that an excess of sludge or residue is made which will require to be determined. Precipitation or clarification may also be employed as a decolorising process, but, from whatever standpoint, the sludge and the specific gravity records should be looked too to provide the necessary check on the efficiency of the working.

CHAPTER VII.

USEFUL TABLES.

APPENDIX A.

TABLE FOR THE CONVERSION OF PERCENTAGE PER TON AND PER CWT.

%	% per ton cwts.	qrs.	lbs.	% per cwt. qrs.	lbs.	%	% per ton cwts.	qrs.	lbs.	% per cwt. qrs.	lbs.
1	0	0	22·4	0	1·12	21	4	0	22·4	0	23·52
2	0	1	16·8	0	2·24	22	4	1	16·4	0	24·64
3	0	2	11·2	0	3·36	23	4	2	11·2	0	25·76
4	0	3	5·6	0	4·48	24	4	3	5·6	0	26·88
5	1	0	0	0	5·60	25	5	0	0	1	0
6	1	0	22·4	0	6·72	30	6	0	0	1	5·60
7	1	1	16·8	0	7·84	35	7	0	0	1	11·20
8	1	2	11·2	0	8·96	40	8	0	0	1	16·8
9	1	3	5·6	0	10·08	45	9	0	0	1	22·40
10	2	0	0	0	11·20	50	10	0	0	2	0
11	2	0	22·4	0	12·32	55	11	0	0	2	5·60
12	2	1	16·8	0	13·44	60	12	0	0	2	11·20
13	2	2	11·2	0	14·56	65	13	0	0	2	16·80
14	2	3	5·6	0	15·68	70	14	0	0	2	22·40
15	3	0	0	0	16·80	75	15	0	0	3	0
16	3	0	22·4	0	17·92	80	16	0	0	3	5·60
17	3	1	16·8	0	19·04	85	17	0	0	3	11·20
18	3	2	11·2	0	20·16	90	18	0	0	3	16·80
19	3	3	5·6	0	21·28	95	19	0	0	3	22·40
20	4	0	0	0	22·40	100	20	0	0	4	0

	1	2	3	4	5	6	7	8	9
lbs. per cwt. ..	1·12	2·24	3·36	4·48	5·6	6·72	7·84	8·96	10·08
lbs. per ton ..	22·4	44·8	67·2	89·6	112	134·4	156·8	179·2	201·6

Specific Gravities.—

The following is the specific gravity of a number of substances, taking water at 1,000.

	Specific Gravity.		Specific Gravity.
Gold	19·325	Nitric Acid	1·217
Silver	10·474	Muriatic Acid	1·194
Copper..	8·878	Milk	1·030
Brass	8·395	Sea Water	1·026
Steel	7·816	Water, Distilled	1·000
Iron, Wrought	7·788	Sodium	·972
„ Cast	7·207	Water, Distilled at 212° ..	·956
Tin	7·291	Linseed Oil	·953
Chromium	5·900	Poppy Oil	·929
Iodine	4·948	Olive Oil	·915
Heavy Spar	4·426	Turpentine	·872
Bremine	2·966	Alcohol, Absolute	·793
Sulphate of Lime	2·311	Citron Oil	·852
Sulphur, Natural	2·033	English Oak	·743 to ·760
Sulphuric Acid	1·848	Cedar	·561
Phosphorous	1·770	Cork	·240
Gum Arabic	1·452		

CONVERSION OF THERMOMETER READINGS.

To Convert	Rule
Fahrenheit into Centigrade ..	Subtract 32, then multiply by 5 and divide by 9.
Fahrenheit into Reamur	Subtract 32, then multiply by 4 and divide by 9.
Centigrade into Fahrenheit ..	Multiply by 9 and divide by 5, and add 32 to the product.
Centigrade into Reamur	Multiply by 4 and divide by 5.
Reamur into Fahrenheit	Multiply by 9 and divide by 4, then add 32 to the product.
Reamur into Centigrade	Multiply by 5 and divide by 4.

Specific Gravity.

Twaddell's Hydrometer to specific gravity	Multiply by 5 and add 1,000.
Specific gravity to Twaddell's Hydrometer	Subtract 1,000 and divide by 5.
Parts per 100,000 *into grains per gallon*	Multiply by 0·7.
Grains per gallon into parts per 100,000..	Divide by 0·7.

BAUME'S HYDROMETER.

Table for Liquids Heavier than Water.

B.	Tw.	Specific Gravity.
1	1·4	1·007
2	2·8	1·014
3	4·4	1·022
4	5·8	1·029
5	7·4	1·037
6	9·0	1·045
7	10·2	1·052
8	12·0	1·060
9	13·4	1·067
10	15·0	1·075
11	16·6	1·083
12	18·2	1·091
13	20·0	1·100
14	21·6	1·108
15	23·2	1·116
16	25·0	1·125
17	26·8	1·134
18	28·4	1·142
19	30·4	1·152
20	32·4	1·162
40	76·6	1·383
60	142·0	1·710

Table for Liquids Lighter than Water.

B.	Specific Gravity.
10	1·000
11	0·993
12	0·986
13	0·980
14	0·973
15	0·967
16	0·960
17	0·954
18	0·948
19	0·942
20	0·936
25	0·907
30	0·880
35	0·854
40	0·830
45	0·807
50	0·785
55	0·764
60	0·745

USEFUL DATA.

To convert—

Grains per gallon into cwts. per million gallons × 1·2755.
Cubic inches into gallons .. .. .. × 0·003604.
Cubic feet into gallons .. .. .. × 6·228.

Water.—*

1 cubic inch of water at 62° Fahr. is equal to 252·286 grains.
0·57665 oz. (avoir.).
0·036041 lb. ,,
1 cubic foot of water ,, ,, 996·458 oz. ,,
1 ,, ,, ,, ,, 62·2786 lb. ,,
1 cubic yard ,, ,, 0 75068 tons.

Lineal.—

1 millimetre = 0·0393701 inches (mm).
1 centimetre = 0·393701 ,, (cm).
1 decimetre = 3·937011 ,, (dm).
1 metre = 39·370113 ,,
1 do. = 3·280843 feet.

* Distilled water free of air.

TABLE SHOWING DECIMAL PARTS OF A SOVEREIGN £1.

s	d	*Decimal.*	s	d	*Decimal.*	s	d	*Decimal.*	s	d	*Decimal.*
20	0	1·00									
19	0	·95 ..	19	3	·962 ..	19	6	·975 ..	19	9	·987
18	0	·90 ..	18	3	·912 ..	18	6	·925 ..	18	9	·937
17	0	·85 ..	17	3	·862 ..	17	6	·875 ..	17	9	·887
16	0	·80 ..	16	3	·812 ..	16	6	·825 ..	16	9	·837
15	0	·75 ..	15	3	·762 ..	15	6	·775 ..	15	9	·787
14	0	·70 ..	14	3	·712 ..	14	6	·725 ..	14	9	·737
13	0	·65 ..	13	3	·662 ..	13	6	·675 ..	13	9	·687
12	0	·60 ..	12	3	·612 ..	12	6	·625 ..	12	9	·637
11	0	·55 ..	11	3	·562 ..	11	6	·575 ..	11	9	·587
10	0	·50 ..	10	3	·512 ..	10	6	·525 ..	10	9	·537
9	0	·45 ..	9	3	·462 ..	9	6	·475 ..	9	9	·487
8	0	·40 ..	8	3	·412 ..	8	6	·425 ..	8	9	·437
7	0	·35 ..	7	3	·362 ..	7	6	·375 ..	7	9	·387
6	0	·30 ..	6	3	·312 ..	6	6	·325 ..	6	9	·337
5	0	·25 ..	5	3	·262 ..	5	6	·275 ..	5	9	·287
4	0	·20 ..	4	3	·212 ..	4	6	·225 ..	4	9	·237
3	0	·15 ..	3	3	·162 ..	3	6	·175 ..	3	9	·187
2	0	·10 ..	2	3	·112 ..	2	6	·125 ..	2	9	·137
1	0	·05 ..	1	3	·062 ..	1	6	·075 ..	1	9	·087

1d. = ·004, 1½d. = ·006, 4½d. = ·018, 7½d. = ·031, 10½d. = ·043.

DIVISION II.

COST GROUPING.

CHAPTER VIII.

REX SULPHATE AND REXUM.

THE following set of accounts shows specimens of process costs where the processes are continuous, there is no identification of material, and the products are continued side by side for the first few initial processes, giving one product, and residuals, which are continued through further processes to solid products.

The examples also show products in which the major cost is practically one of expense, the actual cost of the raw material being infinitesimal as against the gradually increasing cost of the process dealing with the material. It will be noted that, as is usual in all industries where extraction of solids is obtained by water, one of the principal items of cost is that of concentration. As will be noted from the figures, the reduction of the liquor from 2 to 28 Beaume appears to be a heavy one; a comparison should be made with the particulars given in chapter on Concentration with regard to this.

The efficiency of fire heating for evaporation purposes is very good, and the loss of effective units of heat compares favourably with that of the evaporation in vacuo. At the same time, the

increased colour given to the product by evaporation under atmospheric pressure, which necessitates raising the temperature of the mass to boiling point, must not be lost sight of ; and considering the repairs, depreciation, and cost, as against interest on new vacuum plant, the baiance would appear to be in favour of vacuo, subject, however, to the difficulty of finding a suitable metal which would not be attacked by the chemical activities of the product.

The notes at the foot of each account render them practically self-explanatory, and the explanations given in Division I. will have familiarised the reader with most of the technical terms used.

The division of the Coal and Power Charges Account follows the lines laid down in the chapter devoted to this subject, of which the illustrations given are taken from this grouping.

The interest on Plant, Depreciation and Repairs, and Maintenance Accounts follow the principles laid down in the chapters under these special headings, to which the reader is referred for further elucidation.

The titles given to the products, so far as the writer is aware, do not follow any actual product, but the disguise is but thin, and will be readily seen through by any reader who has actual knowledge of the chemical products in question which have been taken for the purpose of this cost group illustration.

The prices at which the various transfers are made inter-departmentally represent their actual value at the stage of transfer, and the proportions between products are based on actual data. The only variation from the normal is that of the Trading Account, in which the prices realised and the profits obtained have been somewhat inflated beyond actual conditions.

It is claimed for this specimen of cost grouping that it enables the board and the management to have before them the monthly cost under each department.

For the purpose of obtaining this summary, the various liquors are charted into percentages of the constituent value, as for instance: —

Lixiviation Process .. 28 Beaume = 22·5 % of resultant product,
Do. do. .. 26 ,, = 20·19 % ,, ,,
Do. do. .. 24 ,, = 19·35 % ,, ,,

and so on with the other Process Accounts; all that is required for the output is the depth of inches in the tank, the specific gravity, and the table of percentages to obtain the results.

Tank A ..	18 inches	=	4,200 gallons	=	22	B ..	92·400
,, B ..	16½ ,,	=	3,400 ,,	=	23·5	B ..	79·900
,, C ..	18½ ,,	=	3,800 ,,	=	21·5	B ..	82·700
,, D ..	17¾ ,,	=	3,600 ,,	=	24	B ..	86·400
					Divided B 28		341·400
					Gallons	..	12·193

Equal to 12·193 gallons at 28 B.
Do. 121·930 lbs. at 22·5 %.

This method may be adopted with any of the calculations required when both gallons and specific gravity vary, in order to obtain the standard solution necessary for attaching a value to same. For various reasons the tanks in this case are not all of the same capacity, a factor which too often needlessly complicates calculations in chemical industries.

The same method applies to the valuation of the residuals. See Recrystallisation Account for the proportionate value of residuals.

REVENUE ACCOUNT, Year ending December 31st 1906.

	£ s d		£ s d
To Development Account, Amount written off for year..	426 17 8	By Balance forward from last year	1,846 17 3
" Directors' Fees	500 0 0	" Trading Account, Balance thereof	4,106 12 3
" Income-tax	205 6 7	" Interest on Plant	427 13 8
" Dividend Account	4,000 0 0	" Rents received	298 7 6
" Balance forward	1,558 1 5	" Transfer Fees	10 15 0
£	6,690 5 8	£	6.690 5 8

DEVELOPMENT ACCOUNTS.

	£ s d		£ s d
To Balance as per last Account ..	2,426 17 8	By Revenue Account, amount written off	426 17 8
		" Balance forward..	2,000 0 0
£	2,426 17 8	£	2,426 17 8

TRADING ACCOUNT for Year ending December 31st 1906.

1906		£ s d	1906		£ s d
Jan. 1	To Stock-in-trade ..	2,347 8 6	Dec. 31	By Sales Account, Rex. Sulphate	9,743 18 8
Dec. 31	" Manufacturing Accounts, Rex Sulphate	3,303 3 3		" Do. Rexum	7,174 12 9
	" Do. Rexum	4,008 0 0		" Stocks on hand at Works, Branch, and Warehouses ..	2,547 11 3
	" Wages and Salaries	1,846 17 5			
	" Rent, Rates, and Taxes .. .	624 13 9			
	" Travelling Expenses	192 14 5			
	" Office and Incidental Expenses	345 16 2			
	" Repairs, Roads, and Buildings	98 17 11			
	" Agents' Commission and Expenses ..	289 18 2			
	" Branch and Warehouse Expenses ..	529 13 8			
	" Carriage, Freights, and Cartage ..	1,424 15 9			
	" Bags, Casks, and Cases	347 11 5			
	" Balance to Revenue Account	4,106 12 3			
	£	19,466 2 8		£	19,466 2 8

GENERAL MANUFACTURING ACCOUNT, December 31st 1906.

1906		£ s d	1906		£ s d
Jan. 1	To Stocks on hand this date	1,845 18 9	Dec. 31	By Rex. Sulphate A/c	3,303 3 3
	" Purchases	3,333 11 7		" Rexum Super ..	3,000 0 0
	" Wages..	1,993 6 3		" Do.	960 0 0
	" Excavation Account	666 12 0		" Do. 2nds ..	1,008 0 0
	" Coal, Coke, Gas, and Water	1,148 9 9		" Residues, Stock forward..	343 14 11
	" Rent of Land ..	66 6 0		" Stocks on hand ..	1,740 8 7
	" Interest on Plant ..	387 4 0		" General Charges ..	98 17 11
	" Depreciation of Plant, &c.	974 14 10			
	" Cartage	38 1 6			
	£	10,454 4 8		£	10,454 4 8

EXCAVATION ACCOUNT.

1906		£ s d	1906		£ s d
Jan. 1	To Stocks of Clay on hand	1,459 6 3	Dec. 31	By Mineral Extraction Account	666 12 0
Dec. 31	" Wages and Labour..	241 5 8		" Stock of Clay on hand this date	1,343 8 11
	" Horse-keep and Stable Expenses ..	52 3 5		" New Roads, &c., carried forward ..	190 16 4
	" Cost and up-keep of Tools, &c.	18 19 7			
	" Repairs, Roads, and Trams	42 14 8			
	" Coal, Oil, and Stores	28 16 3			
	" Rent of Land ..	140 0 0			
	" Rates and Taxes thereon	23 14 7			
	" Haulage Account ..	112 17 6			
	" Depreciation of Plant, &c.	40 9 8			
	" Interest on Plant ..	40 9 8			
	£	2,200 17 3		£	2,200 17 3

The quarries being situated some three miles from the works are connected by a horse tram-road, and the accounts, therefore, owing to this entire separation, are easily kept separate. The Haulage is contract work, and is thus readily ascertainable. The Horse-keep is for the ponies employed in the quarries themselves.

MINERAL EXTRACTION ACCOUNT.

1906		£ s d	1906		£ s d
Jan. 1	To Stocks on hand to date	233 14 0	Dec. 31	By 5,499 cub. yds of Cinder to Lixiviation Account at 42-51d.	974 3 8
	„ Excavation Account	666 12 0		„ Stocks on hand this date	286 13 4
	„ Cost and up-keep of Tools, &c.	50 1 0			
	„ Turning	100 2 0			
	„ Labour Account, Piling	100 2 0			
	„ Rent of Extra Ground	66 6 0			
	„ Interest and Depreciation of Plant ..	44 0 0			
		£ 1,260 17 0			£ 1,260 17 0

Loss in preparation for the whole of the year amounts to 35·45 per cent. on excavated weight, as compared with 34·93 per cent. in the previous year.

Stock of clay on extraction account is only small, the surplus being held at the quarries.

The ground adjoining the works is used only for this purpose, and the rent is, therefore, included in this account.

LIXIVIATION ACCOUNT.

1906		£ s d	1906		£ s d
Dec. 31	To Mineral Extraction Account	974 3 8	Dec. 31	By Liquor to Reduction Account	1,339 11 11
	„ Labour	72 10 8		„ Stocks on hand, Residues forward to next Account ..	134 12 8
	„ Coal and Power Charges	220 6 0			
	„ Repairs and Maintenance	83 12 3			
	„ Interest and Depreciation of Plant ..	123 12 0			
		£ 1,474 4 7			£ 1,474 4 7

The process includes labour in wheeling and spreading the cinder in brick tanks, where it is soaked in water and agitated with rakes. The residues fall to the bottom of the tank and are shifted periodically when the tank is too full for good working. The mud assists in the precipitation of the insoluble matters contained in the solution. The tanks are also aspirated with steam and air to agitate them at four hour intervals, this period being gradually increased during the continuation of the process, and the principal cost of coal is for aspiration and the pumping of the liquor to the next process.

The residues are taken at their value per cent. of the constituents, and the value, therefore, is inclusive of the value of the work performed on them up to this stage.

REDUCTION PROCESS.

1906		£	s	d	1906		£	s	d
Dec. 31	To Lixiviation Account	1,339	11	11	Dec. 31	By Concentration Process Liquor at 28° Beaume	2,097	15	7
	„ Sulphuric Acid ..	308	0	0					
	„ Scrap Iron	176	0	0					
	„ Coal and Power Charges	31	1	8					
	„ Repairs and Maintenance	64	9	8					
	„ Labour	142	18	4					
	„ Interest and Depreciation of Plant ..	35	14	0					
	£	2,097	15	7		£	2,097	15	7

The liquid received from the Lixiviation Process is passed into brick tanks, where it is settled and sulphuric acid and scrap iron is added to the liquor. The labour is principally in agitation and stirring, and also in clearing out the slime and mud which precipitates. This process is worked intermittently with the Lixiviation Process, and one tank is being emptied while the sister tank is in work. The process takes twelve hours.

CONCENTRATION PROCESS.

1906		£	s	d	1906		£	s	d
Dec. 31	To Reduction Process for Liquor	2,097	15	7	Dec. 31	By Liquor to Crystallisation Account ..	5,922	4	1
	„ Recovery Process for Residual Liquor ..	1,225	14	5					
	„ Coal and Power Charges	1,218	15	7					
	„ Repairs and Maintenance	498	12	6					
	„ Labour	124	11	8					
	„ Depreciation of Plant	614	18	4					
	„ Interest on Plant ..	141	16	0					
	£	5,922	4	1		£	5,922	4	1

The liquor coming from the Reduction Process is pumped into the concentration pans, which are heated partly by fire and partly by steam coils in the pans. The cost is excessive, as the pans require practical renewal every two to four years. The depreciation is, therefore, heavy, as also the repairs. There are six pans in use, and the repairs, therefore, practically equalise themselves over the whole plant every year, some of the pans being constantly in repair. The pans themselves, however, are not in themselves expensive, the wear and tear on the flues, bricksetting, and the foundations making the principal item of expense.

CRYSTALLISATION ACCOUNT.

1906		£ s d	1906		£ s d
Dec. 31	To Concentration A/c ..	5,922 4 1	Dec. 31	By Rex Sulphate :— Tns. c. q. lb. 2,202 2 0 14 at 30s. per ton	3,303 3 3
	„ Labour	114 12 4		„ Rexum Mother Liquor to Recovery Process :— 11,225,000 gallons at 5s. 6·5d. per 1,000 galls. ..	3,117 13 4
	„ Coal and Power Charges	40 7 0			
	„ Repairs and Maintenance	123 14 8			
	„ Packages Account ..	167 4 6			
	„ Interest and Depreciation of Plant ..	52 14 0			
	£	6,420 16 7		£	6,420 16 7

The products are separated in this account. The sulphate is now a finished product after the crystallisation is completed and the Rexum mother liquor is gradually decanted from the bars on which the sulphate crystals are formed and the liquor run off to the Recovery Process. The labour is not heavy, the process being practically one of cooling and deposit after concentration. The removal of the crystals is performed after the liquor has been run off, and forms the principal cost of labour in this process. The two products at this stage are practically identical in value; the mother liquor is valued on its test, which is taken at a percentage of its Rexum constituent after allowing for the practicable recovery of same.

RECOVERY ACCOUNT.

1906		£ s d	1906		£ s d
Dec. 31	To Crystallisation Account	3,117 13 4	Dec. 31	By Crude Product to Purification Account, 1,366 tons at 3·181 per ton ..	4,346 13 3
	„ Labour	218 16 5		„ Residual Liquors to Concentration Account, 673,500 gallons at 1·82 per 1,000 gals... ..	1,225 14 5
	„ Coal and Power Charges	76 2 0			
	„ Repairs and Maintenance	146 17 11			
	„ Chemicals	1,980 0 0			
	„ Interest and Depreciation of Plant ..	32 18 0			
	£	5,572 7 8		£	5,572 7 8

Rexum in the crude liquor in separation gives a loss of 9·8% on the theoretical test. The weekly workings show this loss as follows over the year :—

January	8·41	..	9·20
February	9·76	..	9·45
March	9·34	..	9·24
April	9·21	..	9·32
May	9·09	..	9·18
June	9·28	..	9·42
July	8·98	..	9·15
August	9·46	..	9·19
September	9·10	..	8·97
October	8·99	..	9·11
November	9·05	..	9·21
December	9·22	..	9·17

PURIFICATION ACCOUNT.

1906 Dec. 31		£ s d	1906 Dec. 31		£ s d
	To Recovery Process for Crude Product	4,346 13 3		By Firsts, 927 tons at £4·12	3,819 4 9
	„ Labour	64 12 7		„ Seconds, 138 tons at £3·75	517 5 0
	„ Coal and Power Charges	13 9 9		„ Thirds, 301 tons at £1·03 to recrystallise	310 4 2
	„ Repairs and Maintenance	143 18 9			
	„ Interest and Depreciation of Plant..	29 16 0			
	„ Packages	48 3 7			
		£ 4,646 13 11			£ 4,646 13 11

This process consists principally in the recrystallisation of the rexum crystals, which at this stage contain a considerable quantity of dirt and insoluble matter. As received to this account they are grey in colour and require to be a pure white to command the best market price. It will be noted that while the products are separated in the account this is only a matter of departmental quality, and no part of the product is yet in a saleable form for market. There are, however, works which produce the product in this stage only, the crude crystals being sold to refiners who complete the process in much the same way as do the sugar refiners.

The cost of bags in the Packages Account is for storage purposes only, and represents replacements of packages which are for inter-departmental transport.

RECRYSTALLISATION ACCOUNT (A).

1906 Dec. 31		£ s d	1906 Dec. 31		£ s d
	To 301 tons Residuals at £1·03	310 4 2		By 143·2 tons Rexum at £3·9	457 10 3
	„ Labour	63 9 7			
	„ Coal and Power Charges	6 4 5			
	„ Repairs and Maintenance	42 18 1			
	„ Interest and Depreciation of Plant..	34 14 0			
		£457 10 3			£457 10 3

This is an intermediate process, and deals only with the residues from purification. It will be noted that the labour in this process is out of all proportion to the product dealt with, and this is an inseparable factor in the dealing with these residues. It will be also noted that there is a considerable difference in the weight of the product obtained, as the residues contain a considerable quantity of dirt and other impurities.

RECRYSTALLISATION ACCOUNT (B).

1906		£ s d	1906		£ s d
Dec. 31	To Crude Rexum, 138 tons at £3·75 ..	517 5 0	Dec. 31	By Rexum, 192 tons at £5	960 0 0
	„ Do. do. 143·2 tons at £3·90 ..	457 10 3		„ Do. 88 tons at £3 2s. 10d. ..	285 12 6
	„ Coal and Power Charges	8 8 11			
	„ Labour	184 16 3			
	„ Repairs and Maintenance	42 18 1			
	„ Interest and Depreciation of Plant ..	34 14 0			
	£	1,245 12 6		£	1,245 12 6

The loss in product practically ceases at this stage, and these are further received in their full weight. The labour in this process consists in wheeling, sifting, and gathering, and, as considerable time is involved, is out of proportion to the other processes.

RECRYSTALLISATION ACCOUNT (C).

1906		£ s d	1906		£ s d
Dec. 31	To 927 tons at £4 12s. ..	3,819 4 9	Dec. 31	By Refined Super, 600 tons at £5 ..	3,000 0 0
	„ 88 tons at £3 2s. 10d.	285 12 6		„ Seconds Super, 224 tons at £4 10s. ..	1,008 0 0
	„ Labour	125 11 3		„ Stock to recrystallise 182 tons	310 2 3
	„ Coal and Power Account	10 1 9			
	„ Repairs and Maintenance	42 18 0			
	„ Interest and Depreciation	34 14 0			
	£	4,318 2 3		£	4,318 2 3

COAL AND POWER CHARGES ACCOUNT.

	£ s d		£ s d
To Stock on hand, January 1st 1906	325 5 2	By Charges, Lixiviation Account	220 6 0
„ Coal, 1,523 tons at 14s. ..	1,066 5 0	„ do. Reduction do.	31 1 8
„ Do. Cartage of	38 1 6	„ do. Concentration do.	1,218 15 7
„ Wages	134 1 8	„ do. Crystallisation do.	40 7 0
„ Water	51 2 6	„ do. Recovery do.	76 2 0
„ Lighting	31 2 3	„ do. Purification do.	13 9 9
„ Oil, Stores and Packing ..	14 11 7	„ do. Recrystallisation do. A	6 4 5
„ Repairs and Maintenance ..	131 2 4	„ do. do. do. B	8 8 11
„ Depreciation of Plant ..	127 10 6	„ do. do. do. C	10 1 9
„ Interest on Plant	54 18 0	„ Stock on hand at December 31st 1906	349 3 5
	£1,974 0 6		£1,974 0 6

COAL AND POWER ACCOUNT FACTORS.

Department	Pumping Units	Heating Units	Power Units	Total Units	Charges
					£ s d
Lixiviation Process	46·2	90·5	51·1	187·8	220 6 0
Reduction do.	12·2	14·3	—	26·5	31 1 8
Concentration do.	18·6	924·2	96·3	1,039·1	1,218 15 7
Crystallisation do.	24·8	9·6	—	34·4	40 7 0
Recovery do.	12·4	4·6	48·6	65·6	76 2 0
Purification do.	6·2	5·3	—	11·5	13 9 9
Recrystallisation do. A	3·2	2·1	—	5·3	6 4 5
do. do. B	3·6	3·6	—	7·2	8 8 11
do. do. C	4·8	3·8	—	8·6	10 1 9
	132·0	1,058·0	196·0	1,386·0	£1,624 17 3

PLANT ACCOUNT, DEPRECIATION, AND INTEREST CHARGES.

Department	Value at last Stock-taking	Depreciation Charges	Interest Charges
	£ s d	£ s d	£ s d
Excavation Account	240 0 0	40 9 8	40 9 8
Mineral Extraction	440 0 0	22 0 0	22 0 0
Lixiviation	1,236 0 0	61 16 0	61 16 0
Reduction	286 0 0	21 8 0	14 6 0
Concentration	2,836 0 0	614 18 4	141 16 0
Crystallisation	527 0 0	26 7 0	26 7 0
Purification	298 0 0	14 18 0	14 18 0
Recovery	329 0 0	16 9 0	16 9 0
Recrystallisation	694 0 0	69 8 0	34 14 0
Steam Power and Coal	1,098 0 0	127 10 6	54 18 0
	£7,984 0 0	£1,015 4 6	£427 13 8

REPAIRS AND MAINTENANCE ACCOUNT.

	£ s d		£ s d
To Stock at 1st January 1906 ..	1,286 19 7	By Apportionment as follows:—	
„ Purchases, Timber	167 4 6	Mineral Account	50 1 0
„ Do. Iron and Steel, &c.	384 15 9	Lixiviation	83 12 3
„ Do. Sundries	87 11 8	Reduction	64 9 8
„ Wages	648 1 6	Concentration	498 12 6
„ Coal and Power Charges—nil		Crystallisation	123 14 8
„ Depreciation, nil		Recovery	146 17 11
„ General Charges, nil		Purification	143 18 9
		Recrystallisation	128 14 2
		General Charges	98 17 11
		Coal and Power Account ..	131 2 4
		„ Stock at 31st December 1906 ..	1,104 11 10
£	2,574 13 0	£	2,574 13 0

Time and materials are recorded by the foreman by ordinary methods and abstracted weekly to the different departments of the manufacturing. Although the account is abstracted it will be noted that no general charges are included nor is any profit made. A considerable stock of materials and duplicate parts is kept on hand to some extent; the provision of duplicates is made in order to avoid delay in cases of breakdown. The question of interest, depreciation, and general charges has been considered, but it is not deemed necessary to make any apportionment for these, as these charges, apart from the departmental apportionments, will fall in the general results.

MONTHLY COST SUMMARY SHEET, January to December 1906.

Department	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Excavation	·232	·218	·209	·208	·204	·202	·189	·207	·212	·206	·203	·204	·207
Extraction	·098	·097	·096	·100	·103	·108	·099	·096	·092	·087	·083	·082	·090
Lixiviation*	·116	·114	·118	·116	·119	·113	·118	·112	·119	·110	·117	·109	·114
Reduction	·240	·238	·236	·234	·243	·232	·229	·240	·236	·240	·233	·243	·235
Concentration	·798	·805	·804	·802	·813	·802	·809	·796	·804	·814	·820	·819	·807
Crystallisation	·147	·149	·153	·157	·156	·153	·158	·152	·157	·153	·152	·156	·155
Cost to Separation	1·631	1·621	1·616	1·617	1·638	1·610	1·602	1·603	1·620	1·610	1·608	1·613	1·608
Recovery	2·312	2·403	2·298	2·325	2·392	2·378	2·410	2·382	2·401	2·373	2·276	2·269	2·416
Purification	·283	·285	·276	·269	·293	·306	·314	·318	·298	·287	·287	·269	·295
Recrystallisation A	·137	·142	·141	·145	·148	·149	·152	·160	·135	·148	·147	·152	·145
Do. B	·173	·170	·171	·169	·167	·172	·165	·173	·167	·171	·173	·169	·168
Do. C	·206	·208	·210	·212	·214	·207	·206	·203	·201	·200	·199	·198	·209
	4·742	4·829	4·712	4·737	4·852	4·822	4·849	4·839	4·822	4·789	4·690	4·670	4·841

* This cost gives a good illustration of a fluctuation which alternates in regular sequence. The error in this case was due to a fault in measurement. This will often occur in actual practice, and is usually due to gauging with a varying depth of water in glass when sampling for depth.

Weekly Cost Summary.—

The Statement of Cost is prepared weekly for the information of the manager, the wages and other direct expenses being obtained weekly from the Wages Book, Purchase Book, &c. The establishment charges are apportioned on the annual figures, and the consumptions are given weekly.

Department	Total to last week		Expenditure for week		Total to date	Cost Rex Sulphate	Cost Rexum
	£ s d		£ s d		£ s. d	2,202T. £	1,016T £
Excavation ..	655 13 9	·206	10 18 3	·207	666 12 0	·207	·207
Extraction ..	301 13 4	·089	5 18 4	·091	307 11 8	·090	·090
Lixiviation ..	356 15 1	·113	8 13 2	·115	365 8 3	·114	·114
Reduction	746 9 1	·234	11 14 7	·238	758 3 8	·235	·235
Concentration ..	2,549 16 7	·805	48 17 6	·809	2,598 14 1	·807	·807
Crystallisation ..	488 14 2	·153	9 18 4	·154	498 12 6	·155	·155
Total to Stage ..	5,099 2 0	1·600	96 0 2	1·614	5,195 2 2	1·608	1·608
Recovery	2,400 0 6	2·414	54 13 10	2·418	2,454 14 4	..	2·416
Purification ..	293 16 6	·295	6 4 2	·293	300 0 8	..	·295
Recrystallisation A.	147 6 1	·145	..	·145	147 6 1	..	·145
Do. B.	170 17 3	·168	..	·168	170 17 3	..	·168
Do. C.	203 9 5	·209	8 15 7	·207	212 5 0	..	·209
£	8 314 11 9	4·831	165 13 9	4·845	8,480 5 6	1·608	4·841

It is to be noted that the costs as per summary of the Rex Sulphate is £1,608, while the sulphate is taken out of the Crystallisation Process as at 30s. per ton. The actual cost varies from season to season according to the quality of the clay. This is carefully tested monthly for its constituent value, and the result of the analysis is reported to the monthly meeting of the Board. This question, with regard to the quality of the clay, is one of the subconscious problems of the business which never appear in the accounts, but which nevertheless exists as a factor of the greatest magnitude in its probable effect on the welfare of the company.

In this case the initial cost of production is taken at the same rate per ton up to the point of separation of the sulphate. The actual bulk dealt with up to this point in cubic yards is practically equal, the proportion being as 277 to 274 units, which practically gives no difference in cost of handling.

CHAPTER IX.

COST GROUPING.

THERE is necessarily considerable difficulty in submitting a practical illustration of the matters which have been explained in the first division of this volume. It may be urged that in the following illustration a long distance has been travelled from the duties of an Auditor and Chartered Accountant. To prepare and verify any system of Cost Accounts, however, involves in itself the dealing with the information obtained from the views of criticism, and in the case of Process Accounts it does not seem possible to judge as to the value of these, unless we are prepared to apply to the figures when obtained some basis of measurement.

The following illustration, therefore, provides, in the first place, a Raw Material Account, Coal and Power Account, subdivided into Power, Lighting, and Heating Accounts, from which the charges to the various departmental accounts in these items originate. To these accounts are appended tables of factors, which, by the aid of the notes to each, and in the light of special information contained in the chapter on Coal and Power, should be self-explanatory.

It may be urged that the system thus illustrated may be regarded as a special case, but then every process may be special in some particular phase of its accounting. The information, however, disclosed in the accounts, by which the gradual building up of the cost is obtained, should provide a basis on which similar divisions of expense and routine may be projected, and in view of the explanations attached, which are the result of years of experience in the building up of accounts

into the forms here given, many points of interest will occur to the reader for future use.

There are several points of novelty in the system, notably the breaking out of Process Accounts in cases where measurement of raw material at stages would be inadmissible; and, again, where no good purpose would be served by following the raw material through any particular process, as in the maceration process, thereby avoiding many pitfalls and dispensing with considerable expense in the cost methods.

It would be well to compare the Concentration Account in this group with that of Group 1, and note the difference in expense of open firing and vacuo concentration, in which the explanation given in the special chapter on Concentration will prove useful.

The treatment of Repairs, Interest on Plant, and Depreciation all call for careful consideration, while the ease by which the Cost Accounts are focussed in the Cost Summary forms a special feature in the arrangement of same. The explanations which are given to secure the Cost Summary are sufficient to put the reader in touch with the criticism of the cost, and may be supplemented by reference to the special chapters.

We may take for illustration an industry providing two principal products and a number of subsidiary products from the same raw material, which differs largely from the other illustration in this section by reason of the greater complexity of the problems with which we have to deal.

RAW MATERIAL ACCOUNT.

	£ s d		£ s d
To Stocks on hand, 786 tons at £4 2s. 6d. ..	3,242 5 0	By Sortings A.	54 10 8
„ Purchases Material, 6,100 tons at £4 5s. ..	26,825 0 0	„ Do. B.	189 12 6
„ Carriage	2,287 10 0	„ Do. C.	326 14 11
		„ Stocks on hand, 534 tons £4	2,136 0 0
		„ Extraction A. Account..	29,647 16 11
	£32,354 15 0	6,196 tons at 4·79 by difference	£32,354 15 0

COAL AND POWER ACCOUNT.

	£ s d		£ s d
To Balance Coal in Stock	343 18 6	By Lighting Account ..	162 9 0
" Purchases Coal, 14,400 tons at 3s. 6d. ..	2,520 0 0	" Heating Account ..	1,862 10 0
" Wages, Stokers :—		" Power Account	1,500 15 10
4 Men at 2s.	400 0 0	" General Charges ..	61 15 0
2 " £1 5s. ..	155 0 0	" Extraction A. Account	555 7 1
" Boiler Cleaning and Scraping	48 0 0	" Stock in hand	620 17 6
" Oil, Stores, Packing	56 19 4		
" Haulage and delivering Coal	360 0 0		
" Repairs and Maintenance	154 4 7		
" Interest on Plant ..	260 0 0		
" Depreciation of Plant	390 0 0		
" Lighting Account ..	75 12 0		
	£4,763 14 5		£4,763 14 5

In the case of Extraction A. Account the proportion is arrived at separately, owing to the fact that one boiler is separately worked for this department's heating requirements, and the coal is separately tallied, the proportion of fixed charges being added based on the quantity of coal used for this separate boiler.

POWER ACCOUNT.

	£ s d		£ s d
To Coal and Power Account	1,500 15 10	By Balance forward	114 18 6
" Interest on Plant ..	75 0 0	" Extraction A.	756 0 0
" Depreciation	112 10 0	" Maceration	101 10 0
" Wages	212 0 0	" Extraction B.	50 15 0
" Repairs, Maintenance	146 17 8	" Concentration	190 15 0
" Balance forward ..	325 5 0	" Drying	339 10 0
		" Warehouses	14 0 0
		" X. Department	528 10 0
		" M. Department	276 10 0
	£2,372 8 6		£2,372 8 6

Note.—The actual charge is worked out at £1 11s. 9d. per unit, but £1 15s. 0d. is charged herein. The balance is carried forward as a secret reserve against coal fluctuations in future years it will be noted that a difference of 3d. per ton on the quantity of coal purchased makes a difference of £180, and, having regard to the low price at which the coal is purchased, the difference would not be too great if it were doubled.

POWER ACCOUNT FACTORS.

	H.P.	Units		Charges £ s d
Extraction A	80	432		756 0 0
Maceration	16	58		101 10 0
Extraction B.	8	29		50 15 0
Concentration	24	109		190 15 0
Cutting and Cooling				
Drying	48	194		339 10 0
Warehouses	6	8		14 0 0
X. Department	42	302		528 10 0
M. Department	40	158		276 10 0
W. Department				
			at 35s.	
	264	1,290	per unit	£2,257 10 0

The H.P. gives the actual load in full work. For obtaining the units this is multiplied by the hours running per day and night, and by the number of days per annum. The results are given in 1,000 units, and which are for purposes of calculation omitted. For instance, 80 H.P. runs 18 hours out of the 24 hours, and the working days are taken at 300, thus—

$$80 \times 18 \times 300 = 432{,}000, \text{ which gives } 432 \text{ units.}$$

The same apportionment is pursued in the other items. All engines and pumps are taken by indicated horse-power under full load, and in the hours allowance is made for time running light.

HEATING ACCOUNT FACTORS.

	Units	Charges £ s d
Extraction B.	839	839 0 0
Concentration Department	542	542 0 0
Cutting and Drying	100	100 0 0
Drying Department	236	236 0 0
Warehouses	75	75 0 0
X. Department	535	535 0 0
M. Department		
	2,327	£2,327 0 0

The actual calculation works out at 19/42 per unit. As in the Lighting Account, a small profit is made which is carried forward as a secret reserve against any fluctuation in price of coal, &c.

HEATING ACCOUNT.

	£	s	d		£	s	d
To Coal and Power Account	1,862	10	0	By Balance forward.. ..	83	12	2
„ Repairs and Maintenance	124	16	3	„ Departmental Charges as follows:—			
„ Interest on Plant ..	124	14	0	Extraction B.... ..	839	0	0
„ Depreciation	99	12	0	Concentration ..	542	0	0
				Cooling, &c.	100	0	0
				Drying..	236	0	0
				Warehouses	75	0	0
„ Balance forward ..	198	19	11	X. Department ..	535	0	0
	£2,410	12	2		2,410	12	2

In this case the charges for heating represent the steam required for boiling and extraction purposes, as distinct from that supplied to engines and pumps. It will be noticed that the H.P. is taken at 35/ per 1,000 units or H.P. hours, and as this includes coal and all charges, including interest on plant, it is fairly proportionate. In the case of the Heating Account the factors are not so readily apportioned, but the case of water required to be heated is taken, gallons multiplied by the difference in temperature, thus constituting a unit for heating. In the case of concentration the gallons evaporated are calculated on the weekly totals, but for further particulars see the chapter on Coal and Power Account, giving details of these apportionments.

LIGHTING ACCOUNT FACTORS.

	Light	Power	Total		Charges £	s	d
Extraction Department A...	42	48	90×4	360	162	0	0
Maceration Department ..	14	28	42×2	84	37	16	0
Extraction B...	28		28×2	56	25	4	0
Concentration Department	14		14×2	28	12	12	0
Cutting and Cooling.. ..	52		52×1	52	20	18	0
Drying Department.. ..	74		74×1½	111	49	19	0
Warehouses	96		96×½	48	21	12	0
Offices and Roads	48		48×½	24	10	16	0
X. Department	42		42×1½	63	28	7	0
M. Department	58		58×½	29	13	1	0
W. Department	82		82×½	41	18	9	0
Coal and Power	44	40	84×2	168	75	12	0
	594	116	710	1,064	£476	6	0

LIGHTING ACCOUNT.

	£ s d		£ s d
To Coal and Power Account	162 9 0	By Balance forward ..	48 2 3
" Repairs and Maintenance	79 16 3	" Extraction A. Account	162 0 0
" Interest on Plant ..	69 0 0	" Maceration	37 16 0
" Depreciation	110 8 0	" Extraction B.	25 4 0
" Wages	46 19 0	" Concentration	12 12 0
" Balance forward.. ..	55 16 0	" Cooling and Cutting ..	20 18 0
		" Drying Department ..	49 19 0
		" Warehouses	21 12 0
		" Offices	10 16 0
		" X. Department	28 7 0
		" M Department.. ..	13 1 0
		" W. Department ..	18 9 0
		" Coal and Power Account	75 12 0
	£524 8 3		£524 8 3

The Electricity Department provides both light and power; all current, however, for simplicity is calculated as equal to 16 candle-power lamps, and the lighting periods are taken as six hours, thus 90×4 periods of six hours $= 360$ 16 candle-power lamps, and so on. In Extraction A. the length of the week is taken into account, as this department runs on Sundays.

EXTRACTION A. ACCOUNT.

	£ s d		£ s d
To Raw Material Account, 6,196 tons at 4·79 ..	29,647 16 11	By Product No. 1—743 tons 10 cwt. at £15 11s. ..	11,561 18 0
" Wages	693 17 4	" Product to M Department—309 tons 16 cwt. as 348 tons 10 cwt. at £4 5s.	1,477 2 6
" Repairs and Maintenance	216 15 8		
" Interest on Plant.. ..	270 0 0		
" Haulage and Stable Expenses	81 16 4	" Maceration Department —3,903 tons 14 cwt. as 4,215 tons 19 cwt. at £5 .. .. .. (Loss in Moisture—Raw Material 888 tons 1 cwt. net)	21,079 15 0
" Chemicals	1,200 16 4		
" Depreciation Account ..	510 0 0		
" Lighting Account ..	162 0 0		
" Heating Account.. ..	555 7 1		
" Power Account	756 0 0		
" Balance forward	24 5 10		
	£34,118 15 6		£34,118 15 6
		Balance forward ..	24 5 10

Note.—The prices at which the departmental transfers are taken are in accordance with market conditions. The differences in weight are the calculated additions in the moisture content to bring the material to the selling percentage of moisture

which the M. Department usually despatches its goods at. In the other department the moisture content deficiency is replaced owing to the material being saturated in the next process.

EXTRACTION A—CHEMICAL ACCOUNT.

	£ s d		£ s d
To Stock at Jan. 1st 1906 ..	385 11 8	By Extraction Account ..	1,200 16 4
„ Purchases for Year, D/D carriage paid	1,234 2 2	„ Stock at December 31st	418 17 6
	£1,619 13 10		£1,619 13 10

Note.—In the case of Product No. 1 the sale of this is under contract for weekly deliveries, and the actual make is despatched so as to close up the account automatically.

There is no complication of moisture in the Product No. 1 Account, which is taken into account throughout at the refined weight.

PRODUCT No. 1 ACCOUNT.

	£ s d		£ s d
To Extraction A Account, 743 tons at £15 11s. ..	11,561 18 0	By Sales—743 tons 10 cwt. at average of £20 10s. per ton	15,241 10 0
„ Packages	781 5 0		
„ Carriage	495 10 0		
„ Discount and Brokerage	529 12 9		
„ Balance to Trading Account..	1,873 4 3		
	£15,241 10 0		£15,241 10 0

MACERATION PROCESS ACCOUNT.

	£ s d		£ s d
To Chemicals	1,482 12 6	By Product No. 2 Account, being amount of gain due to this process in decolorisation of product or special A. Class 464 tons	1,624 0 0
„ Wages	224 6 8		
„ Lighting	37 16 0		
„ Power	101 10 0		
„ Depreciation	57 10 0		
„ Interest on Plant ..	92 0 0		
„ Repairs Maintenance ..	86 13 8	„ B. Class, 501 tons ..	501 0 0
„ Balance forward ..	41 11 2		
	£2,124 0 0		£2,124 0 0
		Balance	41 11 2

The charge being to some extent dependent on the quantity of product manufactured, an average charge is made annually, and the balance over five years, owing to stoppages, &c., is very slight, amounting only to a few pounds.

EXTRACTION B. ACCOUNT.

	£ s d		£ s d
To Raw Material from Extraction B. Account through Maceration Department	21,079 15 0	By Liquor to Concentration Account, 842,624 gallons at average of Tw. equal to % of finished Product = 965 tons at £18 18s.	17,453 7 3
„ Heating Account ..	839 0 0		
„ Power Account ..	50 15 0		
„ Lighting Account ..	25 4 0		
„ Interest on Plant ..	92 5 0		
„ Wages	312 10 0		
„ Depreciation of Plant..	92 5 0		
„ Repairs Maintenance ..	114 12 3	„ Residues to M. Department, 2,374 tons 3 cwt. as at 12% Moisture, 1,717 tons 13 cwt. at £3 per ton	5,152 19 0
	£22,606 6 3		£22 606 6 3

The calculation of the weight at 12 per cent. moisture follows the lines on which the M. Department received residue from the Extraction A. Department is charged out.

In this process the material is worked on the continuous system; starting at 10 p.m. Sunday it goes continuously to the following Saturday at 3 a.m., when the last liquors are run off. The week's work is finished out in the week, and the following working details may be of interest.

During the week the first vessel remains in work for ten hours, giving with emptying and filling a twelve hours' process. The second vessel is filled three hours after, the third another three hours later, and the fourth three hours later still, the fifth three hours later still, and the sixth and last therefore fifteen hours after the first vessel. They are emptied in this rotation and fresh material is, therefore, being introduced into the working *pro rata* with the exhaustion of the raw material already partially completed, thus maintaining a constant flow of extraction liquor at a steady specific gravity. The beginning and end of the process give weaker liquors, as will be seen from the summary of one week's work on one battery.

These liquor returns form the basis of the credit to the Extraction B. Account, so far as this part is concerned, and are readily totalled to the standard solution by the method given in the chapter on Concentration.

CONCENTRATION PROCESS ACCOUNT,

To		£	s	d	By		£	s	d
	Liquor from Extraction B.— 842,644 gallons at 6¼ Tw. ..	17,453	7	3		Liquor to Crystallisation A/c.— 268,144 gallons at 18½ Tw. Equal in actual finished product to 965 tons at £19·44 per ton	18,762	19	5
„	Heating Account	542	0	0					
„	Power Account	190	15	0					
„	Lighting Account	12	12	0					
„	Interest on Plant	92	10	0					
„	Depreciation of Plant	116	5	0					
„	Repairs and Maintenance ..	78	16	4					
„	Wages	211	16	4					
„	Chemicals	64	17	6					
					„	Loss on wastage from Evaporation			
							T. c. q.		
						Theoretical yield 989 16 2			
						Actual yield .. 965 0 0			
						24 16 2			
						at £19·44 per ton = £482 11s.			
		18,762	19	5			18,762	19	5

The theoretical yield of product should be stated alongside the actual yield. The difference between the theoretical and actual in this case represents to a large extent differences owing to faulty measurement of liquors. In the Manufacturing Summary appended is given the theoretical against the actual yields in each of the departments, and this return forms the basis of the figures given above and furnishes a weekly index of the efficiency of the process working. The gallons actually produced in this case are calculated from the measurements of the vats, thus the first inch may be 48 gallons, the second inch 20 gallons, and every inch afterwards will represent 20 gallons. It must be noted that most liquor vats dip to one end, and consequently the measurement must always be taken at the deepest end, but the line of the first inch is the level of the vat floor at the highest end. At 18½ Twaddle the moisture present in the product varies from 68 to 75 per cent. at this stage, and the total volume, mass or bulk, therefore, is little criterion of the actual yield. The product when crystallised, but while still hot, is poured out in a thick consistency on to glass tables, where it solidifies in cooling, and is then cut into cakes. Under the

glass a current of water is passing, which assists in congealing the product quickly. The cakes are placed on wire or string netting and conveyed to the Drying Department, where the excess of moisture is removed by heated currents of air passing over the products. These currents are induced by fans running by electricity at various speeds, and which alternate during the continuation of the process. This process takes twelve to fourteen days in the best of weathers, and may be considerably retarded by foggy or damp weather.

CRYSTALLISATION PROCESS ACCOUNT.

	£ s d		£ s d
To Heating	100 0 0	By Drying Account for expense of process transferred on 965 tons of finished product at ·824 per ton	794 7 2
„ Lighting	20 18 0		
„ Repairs and Maintenance	97 12 10		
„ Wages	423 0 0		
„ Depreciation of Plant ..	84 10 0		
„ Interest on Plant	38 10 0		
„ Loose Tools, &c.	29 16 4		
	£794 7 2		£794 7 2

The physical conditions of the product at this stage are such as to preclude any system of measurement, and therefore, while the cost of the working is separately assessed and carried forward in one item into the next process, the unfinished product is not brought into the accounts, as there is no leakage of material.

DRYING ACCOUNT.

	£ s d		£ s d
To Product from Concentration Account, 965 tons at 19·44 per ton	18,762 19 5	By Product, No. 2 Account, 965 tons at 22·29 .. Divided as follows:— A. Class, 464 tons B. „ 501 tons — 965	21,504 18 8
„ Crystallisation Account Debit	794 7 2		
„ Wages	483 16 4		
„ Lighting	49 19 0		
„ Heating	236 0 0		
„ Power	339 10 0		
„ Interest on Plant	454 0 0		
„ Depreciation of Plant ..	230 0 0		
„ Repairs and Maintenance	154 6 9		
	£21,504 18 8		£21,504 18 8

The cost of the drying process is practically identical in both the A. and B. class, and the average price is therefore taken forward.

M. DEPARTMENT.

		£ s d		£ s d
To Stocks on hand .. 1,100 Tons		4,275 0 0	By Residues, sold neat :— 1,206 Tons @ £3 12s. 3d.	4,356 13 6
„ Extraction—			„ „ made up :—	
A A/c. 348 10 @ £4 5		1,477 2 6	„ „ „ M. 949 £4 2s. 6d.	3,914 12 5
B „ 1,717 13 £3		5,152 19 0	„ „ „ N. 1,243 £3 15s. ..	5,661 15 0
„ Purchases 2,140 0 d/d		9,778 13 4	„ „ „ O. 207 £5 5s. ..	1,086 15 0
	5,306 3		„ „ „ P. 323 £6 5s. ..	2,018 15 0
			„ „ „ Q. 79 £8 6s. ..	655 14 0
			„ „ „ R. 205	1,383 15 0
„ Wages		848 16 9	„ „ „ S. 420	2,310 0 0
„ Power		276 10 0	„ Stock on hand .. 680	2,635 0 0
„ Lighting		13 1 0	5,312	
„ Repairs		238 16 7		
„ Interest on Plant		200 0 0		
„ Packages Account		500 15 0		
„ Depreciation of Plant ..		225 0 0		
„ Balance to Trading Account		1,036 5 9		
		£24,022 19 11		£24,022 19 11

X. DEPARTMENT.

	£ s d		£ s d
To Stock of Raw Materials ..	1,989 14 1	By Product No. 3 :—	
„ Purchases do. ..	8,974 15 8	243.75 tons at £14 ..	3,412 10 0
„ Chemical Account	2,348 13 6	„ Product No. 4 :—	
„ Wages and Salaries	3,426 19 2	423·4 tons at £32·84 ..	13,891 0 3
„ Power, Lighting, and Heating	1,091 17 0	„ Stocks on hand	1,725 17 8
„ Repairs and Maintenance ..	421 12 3		
„ Depreciation of Plant ..	348 16 5		
„ Interest on Plant	426 19 10		
	£19,029 7 11		£19.029 7 11

X. DEPARTMENT TRADING ACCOUNT.

	£ s d		£ s d
To Stocks on hand	6,928 16 3	By Sales :—	
„ Manufacturing Account :—		Product No. 3—	
Product No. 3	3,412 10 0	243·75 tons at £21·32 ..	5,196 15 0
„ „ „ No. 4	13,891 0 3	Product No. 4—	
„ Carriage and Freights ..	864 14 10	523·14 tons at £41·2 ..	21,576 8 3
„ Packages, Bags, and Cask Account	468 17 11	„ Stocks on hand	3,726 19 2
„ Discounts	1,968 14 2		
„ Balance forward	2,965 9 0		
	£30,500 2 5		£30,500 2 5

PRODUCT No. 2 ACCOUNT.

	£ s d		£ s d
To Stocks on hand :—		By W. Department :—	
A. 149 15 9 ..		284·75 tons at 22·29 ..	6,347 1 4
B. 286 4 3 at 22·16	9,661 10 9	„ Sales A. :—	
435 19 3		444 tons at 29·7	13,186 16 0
		„ Sales B. :—	
		537 tons at 25·8	13,854 6 0
„ Manufacturing Account—		„ Stocks on hand :—	
965 tons at 22·29	21,504 18 8	A. 49 15 0	
„ Carriage and Freights ..	463 14 8	B. 86 4 3	
„ Packages, Bags, and Casks	340 10 0	135 19 3 at 22·29 ..	2,986 17 2
„ Wages, Packing, &c. ..	168 12 2		
„ Warehouse Expenses, Heating, Light, &c.	88 2 0		
„ Cartage Account	18 12 0		
„ Maceration Process Charges	2,124 0 0		
„ Balance to General Trading Account	2,005 0 3		
	£36,375 0 6		£36,375 0 6

W. DEPARTMENT.

	£ s d		£ s d
To Stocks on hand, 1st January	842 12 6	By Sales :—	
„ Product No. 2 Account : —		A. 120 10 0 at 36/3 ..	4,368 2 9
284·75 at 22·29 ..	6,347 1 4	B. 48 0 0 at 32/6 ..	1,600 0 0
„ Power Account (Gas) ..	86 14 2	C. 58 0 0 at 30/– ..	1,740 0 0
„ Lighting Account	18 9 0	D. 84 0 0 at 28/– ..	2,352 0 0
„ Wages	158 16 5	310 10 0	
„ Packages Account	249 11 9		
„ Repairs and Maintenance ..	48 16 5		
„ Depreciation of Plant ..	15 11 6		
„ Interest on Plant	10 15 0	„ Stock on hand—	
„ Carriage and Freights ..	326 19 7	31st December	436 15 10
„ Cartage Account	12 15 11		
„ Balance to Trading Account	2,378 15 0		
	£10,496 18 7		£10,496 18 7

PLANT INTEREST ACCOUNT.

	£ s d		£ s d
To Revenue Account Transfer..	2,205 13 0	By Coal and Power Account..	260 0 0
		„ Power Account	75 0 0
		„ Heating Account	124 14 0
		„ Lighting Account	69 0 0
		„ Extraction A. Account ..	270 0 0
		„ Maceration Process ..	92 0 0
		„ Extraction B. Account ..	92 5 0
		„ Concentration „ ..	92 10 0
		„ Crystallisation „ ..	38 10 0
		„ Drying „ ..	454 0 0
		„ M. Department	200 0 0
		„ W. „	10 15 0
		„ X. „	426 19 0
	£2,205 13 0		£2,205 13 0

GENERAL TRADING ACCOUNT.

To General Expenses :—	£	s	d	By Product No. 1 Account Balance	£	s	d
Advertising, Printing, and Stationery	481	16	5	" Do. No. 2 Do. Do.	1,873	4	3
Incidental Expenses	131	11	9	" Do. W. Department	2,005	0	3
Postages, Telegrams, and Telephones	248	16	4	" Do. M. Department	2,378	15	0
Travellers' Salaries and Expenses	1,123	17	8	" Do. X. Department	1,036	5	9
General Charges from Power Account, &c.	72	11	0		2,965	9	0
Office Salaries and Management	1,948	17	2				
Show Expenses, Prizes, &c.	279	14	3				
Insurance and Compensation	186	17	4				
Rent, Rates, and Taxes	897	18	7				
Subscriptions and Charities	97	18	2				
Balance to Revenue Account	4,788	15	7				
	£10,258	14	3		£10,258	14	3

REVENUE ACCOUNT.

To Auditors' Fees	£	s	d	By Trading Account	£	s	d
" Directors' Remuneration	105	0	0		4,788	15	7
" Income-tax, Schedule D., &c.	400	0	0	" Plant Interest Account	2,025	13	0
" Balance to Profit and Loss Account	300	0	0	" Rent Receivable	186	10	0
	6,195	18	7				
	£7,600	18	7		£7,600	18	7

PRODUCT No. 2.—COST SUMMARY.

Department	Wages	Repairs	Process Materials	Depreciation	Lighting	Heating	Power	Interest on Plant	Other Expenses	Total
Extraction A. ..	·72	·23	1·25	·52	·17	·58	·78	·28	·11	4·64
Maceration ..	·23	·09	1·54	·06	·04	..	·10	·10	·04	2·20
Extraction B. ..	·32	·12	..	·09	·04	·87	·05	·09	..	1·58
Concentration ..	·22	·08	·07	·12	·03	·56	·19	·09	..	1·36
Crystallisation ..	·44	·10	..	·08	·03	.10	..	·04	·03	·82
Drying	·50	·16	..	·24	·06	·24	·35	·47	..	2·02
	2·43	·78	2·86	1·11	·37	2·35	1·47	1·07	·18	12·62

Add Cost of Raw Material arrived at as follows:—

		£ s d		
Raw Material to Extraction A.		29,647 16 11		
Deduct—				
Product No. 1	11,561 18 0			
M. Department	1,477 2 6			
Do.	5,152 19 0			
	18,191 19 6			
Reconciliation—				
Cost as per Drying Account	22·29			
Maceration	2·20	£11,455 17 5	=	11·87
	24·49			24·49

It would be conceded that the Cost Summary on p. 67 shows a graphic statement of the expense of the building up of the product during the various stages from raw material to the finished articles. With regard to the M. Department, it has been thought best to treat this as a separate account. Taking the various accounts in their order, the notes given at the foot of each, together with the explanations given in the first division of the book, will afford the reader a general grasp of the operations involved. We may, however, note the following further explanations:—

Raw Material Account.—

The sortings A., B., and C. are the actual weights taken weekly on their transfer from the Extraction A. Department to the warehouses, and consequently agree with the Day Book totals. It is possible, by a little co-operation on the part of the works management, to invoice the whole year's production in these by-products by December 31st, owing to the requisite time for clearance being afforded by the Christmas holidays.

Extraction A. Account.—

The product No. 1 is the actual invoice weight, the by-product is bagged in packages of even weight, and the weekly transfer gives the credit for this. The Maceration Department is obtained by an automatic weighing machine at the delivery end of the conveyor from the Extraction A. Department, and, being self-registering, there is no difficulty in thus ascertaining credit.

Extraction B. Department.—

On p. 30 will be found a form of weekly return, showing the method by which the yield in gallons is obtained, and which is sufficiently explanatory.

Concentration Department.—

The return from Extraction B. Department also serves to give the particulars from this department. A further form of return, however, will be found on p. 32, of vacuum pan working, from which the weekly details are obtained. A subsidiary return also shows the difference in the details given by concentration in vacuo, in the case of vacuum pans, as compared with the film evaporator.

Drying Department.—

This output is the actual weekly weight bagged. The baggers are paid by weight; the enumeration is verified by the warehouseman for wages purposes, and therefore presents no difficulty.

M. Department.—

It has not been thought necessary to take this account in detail, as the ramifications are numerous. The special headings are extremely technical, and are therefore not of general interest.

W. Department.—

Transfers are made weekly from warehouse stock. They are in bags of even weight, and no difficulty arises herein.

X. Department.—

This department could, if space permitted, be treated on exactly the same basis as product No. 2; the actual Cost Accounts are so designed, and a Cost Summary of the X.

COST SUMMARY CRITICISM.

The figures of the Cost Summary having now been obtained, it may be noted that, although the accounts given disclose the annual totals, they are made up weekly, and that the whole of the credits in the accounts are obtained by weekly totals and

from the returns made from each department daily, and summarised on to weekly sheets. The unit being a weekly one, the accounts can be prepared at short notice for any number of weeks. We pass now therefore to the larger question involved in the consideration of the figures shown in the Cost Summary, and which it is now proposed to criticise from an accountancy and economical standpoint.

Wages.—

The total wages cost, as shown by the Cost Summary, comes out at £2.43 per ton, calculated on the finished product, and the first item in the Wages Summary is that of the Extraction A. Department, equal .72 per ton.

As will be seen from the account, the department handles 6,196 tons inwards and 4,212 tons outwards; the product No. 1, being in semi-liquid form, is not taken into account in this. We have, therefore, a charge for labour as distinct from process wages, which requires to be divided if we are to deal closely with this item.

Having regard to the chapter on Transportation, and the figures there given, we set our summary out as follows:—

	£	s	d
6,196 tons shovelled out of trucks at, say, 6d. per ton..	154	13	0
6,196 tons, hand-sorted ,, 6d. do. ..	154	13	0
309 tons bagged and conveyed ,, 6d. do. ..	7	14	0
4,215 tons packed in trams, &c. ,, 3d. do. ..	52	14	0
Making a total of	369	14	0
for labourage or equal to ·38 of our total ·72, and thus leaving for operating or process wages a sum of	324	3	4
	£693	17	4

We may therefore pass this item as being justified from the point of economy.

Maceration Department.—

Here we have 4,212 tons tipped, and the same quantity, but considerably increased in weight by the absorption of water in the steeping process, the moisture of the raw material into the Maceration Department is 5.2 per cent. The raw material passing from the Maceration Department to Extraction B. Department possesses a range of moisture of from 38 to 47 per cent., showing an increase in the moisture of 32.8 to 41.8 per cent. In consequence, not only is the weight increased, but also the bulk, and if we approximate the total weight at 5,800 tons we shall be in accordance with the result of tests made at various times at this stage. We have, therefore, 4,212 tons inwards, 5,800 outwards, making together a total of 10,012 tons to move, and if we take from the total wages of £224 6s. 8d. the operating wages, amounting to £80 per annum, we have £144 6s. 8d. as a cost of moving 10,012 tons, or equal to 3.4d. per ton. This cannot be considered in any way excessive.

Extraction B. Department.—

We have here an operating cost of £178, leaving £234 for labourage. For this amount we have to handle 5,800 tons inwards, 2,374 tons outwards, making a total of 8,174 tons in all. In addition to this there is the cleaning of the vessels in which the extraction is performed, and as the process is continuous, involving twelve-hour shifts night and day, the figures cannot be regarded as in any way excessive.

Concentration Department.—

The returns given in this chapter will afford the reader a fair summary of the work carried out by this department. As in Extraction B. the work is continuous from Sunday 10 p.m. to Saturday noon, and consequently the wages equal .22 per ton. Practically all operating costs involve a higher rate than in the case of labourage.

Cutting, Cooling, and Drying.—

The wages in these departments—crystallising .44 and drying .50, making together .94—will appear to be higher in proportion than in some of the other departments. So far as the Crystallisation Department is concerned, the plant is thoroughly modern, but the conditions under which the same is worked could be substantially improved. The distance over which the work is carried is considerably extended, owing to structural conditions, and it is estimated that under normal conditions this cost could be brought below .32 per ton. With regard to the drying, this is old-fashioned and clumsy, and the wages cost in this case is altogether out of proportion to modern conditions. It will be noted, however, that the interest on the plant in this case is practically equal to the wages, and has been considerably more. Further alterations and improvements await the reduction by depreciation, and some considerable instalment will be anticipated on the first convenient opportunity.

Repairs and Maintenance.—

The wages in this case are .77, equal to £743. This expenditure depends, of course, on the nature of the plant and the time running. As will be noted, the greater part of the plant is working 132 hours per week. The actual wages included amount to £467, leaving £276 for materials. The total appears high, but, as will be noted, the repairs are heaviest in those departments where they would necessarily occur.

Process Materials.—

The total expenditure in this case—namely, 2.85—is one which is admittedly a matter for technical criticism, as it will be noticed that the chemical process in Extraction A. Department amounts to 1.25, as against 1.54 in the maceration. So far as the Cost Accounts are concerned, they have disclosed the condition of affairs, and the continuance is a matter for which the responsibility must rest with the management.

Depreciation.—

The full details of this may be gathered from the Plant Interest Account, and it will be noted that both Extraction A. and the drying amount to .76 of the 1.11. This is due in the first place to a special obsolescence in Extraction A. Department, and also in the drying.

Lighting.—

On p. 58 will be found the full particulars of this.

Heating and Power.—

Heating £2.34, power £1.47, equal £3.81.

In view of the information given in the chapter on Coal and Power, the figures of the Cost Summary provide material for considerable criticism. It is evident that the steam generating plant is far from efficient. There is one item, however, in the Coal and Power Charges Account—namely, £360 for haulage and delivery of coal. As will be seen, this item forms a considerable item in the expenses side of the account, and if to this is added the depreciation and interest on plant charged we have a total of £1,010 in these three items, or nearly 25 per cent. of the total charge.

Interest on Plant.—

The inclusion of this item in the costs of process is a matter on which opinions are divided. In an industry such as the chemical process, where expenses of process considerably outweigh the expense of raw material, there appears to be no better way of marking the effect of the reduction of the expenses by new plant than by the inclusion of the interest as a portion of the process cost. The Plant Interest Account, in which the charges are brought to credit, shows the total, which is equal to a Plant Capital Account at 5 per cent. of £44,040, and with a huge plant such as this, producing only a net profit of £4,788, it is

evident that the inclusion of interest in the Process Cost Accounts is amply justified.

Classification of Costs.—

A further considerable service which is rendered by this method of costs is the facility with which the cost of the raw material can be shown against that of process, and an account in which the proportion of direct cost, indirect cost, direct expense, and indirect expense may be classified is of great advantage. The following table shows this in a readily appreciable form.

COST SUMMARY.

	Per Ton	Total
	£	
Direct Cost:—		
Raw Material	11·87	
Process Material	2·86	
Wages	2·43	
		17·16
Indirect Cost:—		
Heating	2·35	
Power	1·47	
Lighting	·37	
		4·19
Direct Expense:—		
Repairs	·78	
Other Expenses	·18	
		·96
Indirect Expenses:—		
Depreciation	1·11	
Interest on Plant	1·07	
		2·18
		24·49
Reconciliation:—		
Drying Account	£22·29	Maceration £2·20 Total £24·49

Arrangement of Books and Accounts.—

The arrangement of the books and accounts must of necessity vary somewhat, to suit not only the particular class of business, but also to suit the size of the business and the clerical staff.

The matter divides itself naturally into two heads—the Commercial and the Technical—and the dividing line must be

drawn with all due respect to the amount of secrecy which it is desired to maintain with regard to the manufacturing particulars.

There are two main factors to take into consideration in the system of bookkeeping to be instituted. On the one hand, you must have a set of books complete in themselves for dealing with outside interests, which include the auditors, and which must be clear and distinct in themselves, and which may also be required to be produced at any time in a Court of law.

Hence we have Cash Book, Day Book, Sales Ledgers, Purchase Book, Bought Ledger, Nominal Ledger, Private Ledger, and Journal, all except the two latter in singular or plural.

In the case of Group 2 of Division II., where there are a number of departments it will be convenient, in order to save analysis, to have Departmental Day Books, and, if possible, Departmental Ledgers, where the customers are distinct. It will also be a convenience to have Departmental Purchase Books and Ledgers in similar fashion. Although at first sight this would appear to involve a great number of books where there are any considerable number of transactions, the time saved in being able to deal with the Day Books and Purchase Books and Ledgers separately for orders, carriage, checking, &c., is very considerable, and the cost is the same in the end, whichever method is adopted.

It is essential that the weekly totals of both Sales and Purchases should be readily available, and therefore that the various figures in the weekly returns should represent the Day Books and Purchase Books as far as possible.

With regard to abstracts, these are preferable to the analysis by columns. Presuming that our Day Books and Purchase Books contain Weight columns as well as Value, it is advisable

to also insert a Carriage column, which can be extended, so that the d/d values in Purchase Books and f.o.r. values in Day Books may be readily ascertainable. These columns are credited to the Carriage Accounts (Memorandum), and act as a contra to the carriage debits from the Railway Accounts.

The Cash Book will contain Discount, Detail, and Bank columns on each side, in addition to Voucher and Posting columns, and the abstract of the cash received for the various Ledgers is abstracted out into the columns of a separate Cash Abstract Book, the totals of which give the required figures for the Controlling Ledger Accounts for each Ledger, including the discount. In entering the Cash Book, which is practically a copy of the Bank Pass Book in the Bank columns, no cash in hand being kept, the entries for each day are arranged in the order of the Ledgers, classified so as to minimise the abstracting.

From the particulars thus rendered available, a form of Weekly Return is made up showing the movement of the commercial side, and which, with the technical weekly returns of output and the Cost Ledgers, is available every Monday night for the Board.

It will be seen that we have thus provided the foundation accounts for our cost system.

The extent to which costs are affected by the fluctuations in output affects chemical industries to a perhaps greater extent than any other class. This result is due principally to the fact that the proportion of the total cost incurred in the raw material is small compared with that of the process costs.

In the Group No. 2, Division II., this is shown in the Cost Summary very plainly.

In this case the original raw material, which governs the entire output, and consequently in that respect the most

important factor, gives a cost of only .207 per ton, as against a total cost of £4.841 in the finished product.

The problem, therefore, in many cases is, to what price is it possible to go to procure the raw material, as against the increased expense per ton due to diminished output?

The answer to this problem must of necessity depend on the particular industry, inasmuch as the extent to which wages, coal, and other expenses can be reduced proportionately with the output depends on the special circumstances.

We may, however, point out several factors which are common to all industries in relation to this point.

Taking Group 2, Division II., as our basis, we may assume that a reduction of 10 per cent. in output will afford little or no opportunity for economy in either of the main factors of expense —viz., Wages, Coal and Power, or Repairs—while Depreciation and Interest on Plant, and all indirect expenses, will remain the same. In theory the coal and power charges should show a reduction, but in actual practice it will be found that the maintenance of the same head of steam will require practically the same (not quite) amount of coal.

If it were possible to arrange to work, say, five days per week instead of six, some saving could be effected by shutting down some of the steam generating plant on the last day. From actual practical experience, however, the amount of waste by extra condensation in steam pipes, the loss by leakage, and the extra steam required to heat up again will outweigh the saving which would otherwise accrue, and it must be remembered that the steam practice in chemical works usually is not of the highest standard.

Another factor of importance is, in chemical processes, that the length of time taken in some one process renders it necessary to maintain an effective head of steam for its requirements.

If we consider that a steam engine without load means an expense in working against the atmospheric pressure alone, coupled with the low percentage of actual efficiency obtained in it, even when working under the most favourable conditions, enough has been said to show that a reduction of output of, say, 10 per cent., which means perhaps only a reduction in some processes of a few horse-power on the load, cannot be expected to give a diminished cost proportionate with the decrease in output.

If we take the Group 2, Division II., the Cost Summary (p. 67) gives the proportionate cost of each process under the different heads of expenditure, and as in this case the proportion of the cost of the raw material is nearly half the total cost, it will be interesting to separate out those factors which would be affected by a reduction in output, and see to what extent a diminished output would affect the weekly cost.

The form given, although for the whole period, is a cumulative one, and is prepared weekly, as also the further summary on (p. 74.)

The notes attached to this group of Process Accounts will render it easy for the reader to follow the arguments.

We may take the basis of a 10 per cent. reduction in output, as before mentioned, and, dividing the wages, we have the following approximation:—

Wages	Process Wages	Handling Wages	Total	Wages—Possible Reduction of	Total Wages
					£ s d
Extraction Account ..	·34	·38	·72	·038	693 17 4
Maceration " ..	·09	·14	·23	·014	224 6 8
Extraction B. " ..	·19	·13	·32	·013	312 10 0
Concentration " ..	·22	Nil.	·22	..	211 16 4
Culling and Cooling..	·14	·30	·44	·030	433 0 0
Drying	·13	·37	·50	·037	483 16 4
	1·11	1·32	2·43	·132	£2,349 6 8

So far as regards the process wages, these represent the skilled labour, and usually on fixed weekly wages, and which would not be affected at all by a 10 per cent. reduction in output. The actual processes would each take the same length of time in operating, and whether the vessels were quite full or 10 per cent. less would not practically affect the labour on them, so far as the process labour was concerned. Assuming that the quantities of the bulk in handling were reduced 10 per cent., and that it were possible to economise by reducing the hours of the labour engaged in transport work, &c., which is placing a most favourable construction thereon, the total saving for the week would represent £6 only; so far as process wages were concerned it would be *nil*, and in actual practice the saving of this £6 would be very problematical. It would be safe to assume that not quite half this saving would result in the wages, or .062 in all.

We pass next to the Repairs, which would not be affected.

Process materials would not be affected, as the cost per ton would be the same, if not very probably a small increase.

Depreciation, Lighting, and Power would not reduce, and in respect to Heating this would not reduce the cost, but might be expected to increase it.

We have, therefore, a saving—very problematical—in wages alone out of the total cost as the only item which would be diminished.

CHAPTER X.

SULPHURIC ACID.

NOTE.—It is not proposed to deal with this illustration *in extenso*, as two examples have already been given which illustrate the principles on which the Cost Accounts are to be based, but the following data will give the stages, and the notes appended will allow of the reader constructing therefrom the *pro formâ* accounts from the total figures set out.

SULPHURIC ACID, in the first place, is one of the principal chemical products, and the industries which are dependent on its production are numerous and cover a considerable variety of trades. Practically, now the raw material consists of pyrites, which usually contain about 33 to 50 per cent. of sulphur, according to quality.

The following are some of the principal grades, with their constituent values:—

	Percentage of Constituent—Sulphur.		
	Minimum per cent.		Maximum per cent.
American Pyrites	39	to	47
Canadian ,, ...	40	,,	42
Spanish ,, ...	48	,,	50
Swedish ,, ...	38	,,	40
Norwegian ,, ...	45	,,	47
French ,, ...	46	,,	48
German ,, ...	46	,,	47
Belgium ,, ...	43	,,	45

Process.—

The pyrites, after crushing, are burnt in specially constructed furnaces, which are operated on the continuous production of vapour or gas. The furnaces are fired in succession.

The gas from the furnaces is passed through towers, where it ascends against water percolating through bricks and coke

until the vapour is absorbed by the water passing into leaden chambers, whence it emerges as an oily liquid. In the process nitrate of soda is used.

The stages of the process are (1) Production of the gas, (2) Conversion into sulphuric acid, (3) Purification, and (4) Concentration.

The Cost Accounts require to furnish the following particulars :—

	Ex Lunge.
Total quantity of pyrites burnt, tons	2,775·6
,, percentage of sulphur constituent	48·8
,, quantity of sulphur purchased in pyrites, tons	1,354·6
,, ,, acid at 106° Tw. produced, tons	6,322·2
,, equivalent in $H_2 So_4$, tons	3,948·2
,, quantity of sulphur in the acid produced, tons	1,290·0
,, loss of sulphur in the process	64·6
Percentage of sulphur lost in the residue	2·69
,, ,, ,, in chambers	2·03
Total percentage of sulphur lost	4 71
Nitrate of soda as at 95% consumed, tons.. ..	50·9
,, ,, consumed per cent. of sulphur produced	3·75
,, ,, ,, ,, of 106° acid	0·80
Real $H_2 So_4$ made per 100 pyrites	142·5
,, ,, ,, ,, sulphur	291·9

The following estimate of cost is taken from a 1906 works, thoroughly modern and up to date in plant and process.

	£	s	d
2,476·80 tons Pyrites, testing 48·50% of Sulphur	1,651	3	0
130 tons of Coal	81	5	0
29·16 tons of Nitrate of Soda	262	5	10
Water	25	0	0
Rates, Taxes, and general charges	83	6	8
Repairs and Maintenance	145	16	8
Working expenses..	250	0	0
Wages	243	6	8
Depreciation and Plant, 12½% on £5,000 ..	625	0	0
	£3,367	3	10

The average cost per ton on 5,760 tons production annually of Sulphuric Acid of 53° Beaume =115 Tw.	14/- per ton.
The cost of Nitre on basis of Acid produced is	0·6 ,,
The interest on Plant per ton of Sulphuric Acid produced is	10/7 ,,
The depreciation charged is equal to	2/2 ,,

The Capital cost of the Plant is as follows:—

	£	s	d	
Furnace Plant	945	16	8	
Chamber Plant	3,041	13	4	
Boilers, Pumps, and Air Compressors	1,145	16	8	
				£5,133 6 8

Leakages in Cost.—

(*a*) Incomplete combustion of pyrites, producing insufficient volume of gas and leaving excess of sulphur in residues.

Excellent working with moderate quantity ores should leave			2½ to 3 per cent.
Good	do.	do. ..	3 to 4 ,,
Moderate	do.	do. ..	5 to 6 ,,

(*b*) Faulty working in the introduction of the nitric acid (from nitrate of soda) in the chambers by:—

Escape of nitre gas into the open air. (Repairs to leaden chambers.)
Loss by nitre compounds left in chambers.
Reactions in the nitre gas.

(*c*) *Sublimation.*—In all processes some portion of the sulphur will be deposited in the pipes and connections.

(*d*) Faulty joints in pipes, furnaces, &c.

(*e*) *Escape of Sulphur Gas into the Open Air.*—The Alkali Act prescribes a maximum of four grains per cubic foot. A fair average escape is from 1.2 to 1.4 grains per cubic foot.

Purchases.—In many cases the pyrites are not purchased outright, but only the sulphur constituent, the residues being returned. The excess of sulphur left in the residues therefore is a total loss.

Pyrites Account.—An account of the purchases, showing analysis of parcels and agreeing with the stocks on hand at the commencement and end of the period, crediting the residues and leaving the net quantity and average price per cent. of sulphur to the Furnace Account.

FURNACE ACCOUNT.

To	£ s d	By	£ s d
Pyrites Account @ 48·23 % 2,476·80 tons net.. ..	1,651 3 0	Gas Account:— 1,194·56 tons Sulphur @ 48·23 % theoretical yield	2,097 3 0
„ Labour Account, breaking up ..	34 17 8		
„ Do. Firing ..	91 17 11		
„ Repairs and Maintenance..	49 13 4		
„ Coal and Power Charges ..	16 17 6		
„ Interest on Plant	47 5 9		
„ Depreciation	113 6 0		
„ Loss of Sulpur, 269 % = 66·62 tons	92 1 10		
£	2,097 3 0	£	2,097 3 0

GAS ACCOUNT.

To	£ s d	By	£ s d
Sulphur Constituent produced:— £2,097 3 0 1127·94 tons less 92 1 10	2,005 1 2	Sulphuric Acid:— 5,760 tons @ 53° Beaume equal to 115 Tw. at ....per ton	3,281 18 4
„ Nitrate of Soda	262 5 10		
„ Power and Coal Charges..	64 7 6		
„ Repairs and Maintenance..	96 3 4		
„ Depreciation	418 15 0		
„ Wages	116 11 1		
„ Water Charges	25 0 0		
„ Interest on Plant	209 7 7		
„ Loss of Sulphur, 2·03 % = 55·27 tons	84 6 10		
£	3,281 18 4	£	3,281 18 4

MANUFACTURING ACCOUNT.

To	£ s d	By	£ s d
Gas Account:— £3,281 18 4 Less 84 6 10	3,197 11 6	Trading Account:— 5,760 tons acid at 115 Tw.	3,623 17 2
„ Working Expenses ..	250 0 0		
„ Depreciation on General Plant	92 19 0		
„ General Charges	83 6 8		
£	3,623 17 2	£	3,623 17 2

The accounts are not worked out fully in detail, for reasons of space. The principal object is to bring up for consideration the special point of the inclusion of the loss on the debit side of the Process Accounts as against the theoretical yield.

This opens up a very wide field for discussion. In the first place, the bookkeeping of the accounts is not interfered with, and by so treating the loss it appears in the process cost as an expense, and can thus be shown by its percentage relation, along with the other expenses, to the theoretical.

If we consider this point in relation to the other *pro formâ* illustrations we should in each case require to have the theoretical yield in each deparment as the credit item, which would be a distinct advantage, especially in those processes where the actual yield of the finished product could not be ascertained in time for inclusion in the accounts.

It may be noticed that in Group 2 the returns are so formulated that the average percentage constituent is readily ascertainable for both the Extraction B. and the Concentration processes in that illustration.

DIVISION III.

ECONOMICS OF COST.

CHAPTER XI.

POWER AND COAL TRANSPORT.

THE movement of the products from the raw material to the finished article is a considerable factor in the cost of the process, and in preparing departmental costs one that requires to be taken into account.

It may appear, at first sight, that this is a matter of management rather than a matter of the Cost Accounts; but if we regard the cost office as the assistant of the management, no item which adds to the actual cost can be omitted from the accounting of the Cost Department.

The importance of this question is emphasised when we consider that the weight of material inwards and outwards in a moderate works may be as much as 600 to 800 tons per week, and that in transportation not only has the material to be moved, but generally an addition to this of 50 per cent. of the containers.

For instance, a railway wagon holding nine tons will weigh five tons, and a man wheeling a barrow holding one hundredweight will be really moving a weight of two hundredweights, and so on.

Not only so, but there is the moving of the empty wagon or tram, so that if the weight moved is taken as double that of the

material we shall not exaggerate. This, again, is to be multiplied by the number of times the products are moved, either in their original, redried, or increased bulk, or weight, and it will be, therefore, seen that the incidence of the transportation arrangements on cost is very considerable indeed.

In preparing an estimate of the work done under this head, the work per mile per hour should be taken, and for chemical work the actual conditions require to be carefully tabulated and the continuity of the work carefully scrutinised.

In taking the proportion between departments it is usual to make each department responsible for the delivery of its product to the following department, basing this rule on the addition of the cost of carriage to the raw material in the initial stage of manufacture.

The cost of transportation varies considerably as to whether the moving force is man, horse, or steam power. The following figures are given by Mr. Geo. Davis in his handbook on "Chemical Engineering":—

Man with Barrow (tipping)	..	2d. per ton for 30 yards distance.
,, (unloading)	..	3½d. ,, ,, ,,
,, (unloading and stacking)	..	4d. ,, ,, ,,
Two Horses with Lurry, 11 miles		8d. per ton per mile.
Hauling Engine per H.P.	..	0·16 ,, ,, hour.

In the latter case, however, the Cost, Interest, Depreciation, and Repairs require to be taken into account.

The cost of transportation is a factor in cost which is an inevitable additional expense in some cases, owing to the arrangement of the manufacturing departments and their proximity to each other. In such cases this addition to the cost requires to be carefully scrutinised and separated from the true cost, as the cost of transportation involved in the bad arrangement of the works is in the nature of an addition to the rental. For instance, no purchaser would be expected to give

the manufacturer a greater market price for his product simply because the cost of interdepartmental transportation is excessive in that particular works.

It will, however, be found that while one works possess some special advantages, say, in railway sidings, water supply, or other facilities, these are generally counterbalanced by some disadvantage.

It will be seen on reference to the notes attached to the Cost Summary of Group 2, Division II, that the criticism of the wage cost must necessarily involve the problem of transportation; not only so, but in the apportionment of the expenditure from the Coal and Power Accounts to the Departmental Accounts, the cost of power requires to be taken into account as one of the factors of the charge.

It is a difficult matter to separate out the transportation charges in some works, as this is actually performed in the process work; and in others the conveyance of the product is arranged from floor to floor, or from one part of the building to the room next door without handling.

On the other hand, and applying specially to chemical industries, it will be found necessary to transport material, or products, from some considerable distances owing to process or other considerations, such as the time required to mature, &c. In this, and in all other cases where the cost is increased by special considerations, it is essential that they should be shown in the Process Cost Accounts as a separate heading, if at all possible. The whole *raison d'être* of costing is to show the management where any economies can be effected, and, therefore, any extraordinary factor of cost must be itemised, if this is to be effectively carried out.

It follows, therefore, that an intelligent appreciation of the factors, which must show themselves in any proper and thorough

system of Cost Accounts, will not overlook the question of transportation charges where these are of moment.

Where mechanical transportation is used, the conveyor or other appliance will generally be found to have been supplied with a definite statement of the H.P. required for its purpose, and these statements are generally definite and specific, having been obtained from actual trials. It follows, therefore, that this H.P., multiplied by the number of hours running, will give the H.P. hours, and this is again readily calculated upon the lines laid down in the Coal and Power Charges Account for departmental charges.

The following memoranda are given by "Laxton's Builders' Price Book," and will be useful in any attempt to gauge the wages paid in connection with the handling of materials:— 15½ cubic feet of chalk weigh one ton; 18 cubic feet of clay weigh one ton; 21 cubic feet of earth, 19 cubic feet of gravel, and 21 cubic feet of sand all weigh one ton. Laxton price for filling into carts, 1s. per cubic yard; filling barrows and wheeling 20 yards run, 1s. per cubic yard. These prices include profit, and therefore, taking 25 per cent. off, would leave these prices per ton of material at about the figure of 6d., which has been taken as the basis of the labour cost. Mr. Davis, in his work on "Chemical Engineering," states that the price of transporting goods by hand-barrow is extensively employed in the majority of chemical establishments, varies with the nature of the material, and 2d. per ton for a distance not exceeding 30 yards may be considered an average price. Substances that have to be carefully unloaded, wheeled to a short distance, will cost 3½d. per ton, and the unloading of a brick kiln will cost 4½d. per ton. In crushing pyrites the cost of steam labour and wear and tear approximates to 3½d. per ton, while hand labour will cost 10d. per ton at least.

CHAPTER XII.

STANDARD OF OUTPUT.

In the case of many chemical works these have been started as small one-man concerns before the time of limited liability, and have gradually evolved themselves out of profits by adding department to department. In very many cases the building has followed a like course of development, and in consequence we frequently find important industries carried on under conditions utterly regardless of cost, and only possible owing to the special price obtained by hereditary connections.

Sooner or later the law of "diminishing return" must necessarily operate, with the result of a disappearance of much of the value of the assets representing buildings and plant.

It is not perhaps too much to say that, equally with inefficient works organisation, coal and other like charges, together with the main factors of the cost of production, are in the same chaotic condition.

To apply to such works a standard of output or production would appear, at first sight, to be futile. Nevertheless, it is with just such a condition of affairs that proper Cost Accounts would be of inestimable value.

In the case of new industries the standard on which the works are to be erected is considered and selected beforehand, and, provided that the plans have been properly prepared and the whole design carried out proportionately, the possible standard of output is ready set up.

In many cases of chemical industries the actual products are entirely dependent on market conditions. A soap-maker may secure a contract for a special industrial soap, forthwith obtain

his raw material, generally possible in one form or another, complete his contract, and then turn to another product altogether to find his next output. Practically, in the case of numerous chemical industries, specialisation has not been carried to any great extent, and if they are not making one product to-day they are making another. Again, there are industries which manufacture only one product, and this continuously during the whole of the year. In the case of the industry which is not specialised the institution of a standard output would appear at first sight impracticable, and we may very well expect to have such a suggestion scouted and ridiculed as visionary and ideal. In fact, it is not saying too much to affirm that the chemical industries will probably be the last group to obtain the benefit of systematic Cost Accounts, owing to the innate conservatism of the present generation.

Again, many chemical industries cater specially for one or two trades. If these trades are brisk, then the chemical business is doing well; and if these trades are slack, the chemical business is doing badly and hopes for better days. The grace of resignation under adverse conditions is one in which the chemical industry particularly excels. It is somewhat surprising that an industry in which so much progress has been made by sheer radicalism in scientific process should be the last to carry its technical experience into its commercial methods. In obtaining, therefore, in such a case a standard of output it is necessary to rely entirely on one's own exertions. The first step is to obtain an analysis of the Day Book, and to take the various classes of products sent out over a period of, say, three years, noting both quantity and weight of each class. An analysis of the raw material and process material purchased should follow.

A schedule is to be then prepared in the form following, which may at first be merely an approximate statement. The stocks on hand at the beginning and end of the year should be dissected,

and the actual production, as distinct from the sales, thus secured.

Where the products are all principal products, without by-products, the matter is less complicated, and there is only the matter of proportion to deal with. Let us take a case in point:

We have a works which produces a variety of single products of varying qualities, prices, &c., and we assume, therefore, as follows:—

Table C1.

	Product			
322 tons	M	at	£5 per ton	£1,610
200 ,,	N	,,	£2 ,,	400
426 ,,	O	,,	£7 10s. ,,	3,195
68 ,,	P	,,	£12 4s. ,,	833
91 ,,	Q	,,	£18 6s. ,,	1,665
140 ,,	R	,,	£35 ,,	4,900
1,247				£12,603

It is at once apparent that neither averages nor any ordinary method of calculation will suffice to embrace these varying quantities and prices in one standard. It will also be conceded that in the example taken the conservatism referred to has been given the fullest consideration in the complexity of the products selected for illustration.

In the first place, we have the dissection of the value to find the actual net value at the works, net naked f.o.r., which is as follows:—

Table C2.

Product	Quantity	Selling Value	Value Net. Naked F.O.R.
	Tons	£	£
M	322	1,610	1,325
N	200	400	268
O	426	3,195	2,827
P	68	833	742
Q	91	1,665	1,483
R	140	4,900	4,620
Total ..	1,247	£12,603	£11,265

We have, further, the approximation of the raw material and wages in the case of each to apply, and which are as follow:—

Table C3.

Product	Quantity	Raw Material	Process Material	Wages	Total
	Tons	£	£	£	£
M	322	468	123	249	840
N	200	97	28	82	207
O	426	618	147	1,235	2,000
P	68	246	173	110	529
Q	91	326	280	289	895
R	140	1,462	820	946	3,228
Total	1,247	£3,217	£1,571	£2,911	£7,699

Table C4.

Product	Quantity	Value Net Naked F.O.R.	Prime Cost as per Table	Balance	Balance per ton
	Tons	£	£	£	£
M	322	1,325	840	485	1·5
N	200	268	207	61	·30
O	426	2,827	2,000	827	1·94
P	68	742	529	213	3·13
Q	91	1,483	895	588	6·46
R	140	4,620	3,228	1,392	9·94
Total	1,247	£11,265	£7,699	£3,566	2·94 average

Now for the purpose of fixing a standard we might, as in the case of "multiple costs," take the best paying product, "R," convert and express our standard in its terms; or we might take an average or medium priced product, and use this as a basis. The arguments for and against these, however, have been fully dealt with in the volume on "Multiple Costs." The considerations affecting the above are entirely dissimilar, however, to the case of standardised products, and we must, therefore, find a specific method of dealing with them.

As may be noticed from the illustrations in the cost grouping division, the cost of production in the case of chemical processes will often lie in the expense of the process rather than in the cost of the raw material, and it will be safe, therefore, to assume that in the case of "Q" and "R" products the considerable margin which exists in the prime costs is due largely to heavy coal and power expense in the production.

On the analysis of the Day Book we find, for three years past, the total sales have been 1,348 tons, 1,474 tons, and 1,247 tons, as above, and the abstract of the different products is as follows:—

Table C5.

Product	1st Year	2nd Year	3rd Year
M ..	460	394	322
N ..	140	182	200
O ..	530	557	426
P ..	54	69	68
Q ..	85	174	91
R ..	79	98	140
	1,348	1,474	1,247

The basis, therefore, to be obtained by any average of these years is not a stable one. It must be borne in mind, however, that the standard it is sought to set up must of necessity represent a measure of earning power, which, after all, is the end and aim to be achieved in any consideration of the relation of cost to selling price.

Taking into account the coal and power charges we are able, by approximating for the excess or difference between the cost of coal generally and that used for "Q" and "R" processes alone, to obtain an estimate that at least £6 per ton of finished product in "R" and £3 5s. of finished product in "Q" represent the excess of coal consumption, and that, so far as the

other processes go, and with regard to "Q" and "R" after taking this excess into account, there are no special items which call for treatment.

We may therefore reduce the balance figures arrived at in Table C4, which will leave us as follows:—

Table C6.

SUMMARY OF OUTPUT FACTORS.

Product	Quantity Tons	Sale Value	Value Net Naked F.O.R.	Raw Material	Process Material	Wages	Excess Coal Cost	Total Prime Cost	Balance	Balance per ton
		£	£	£	£	£	£	£	£	£
M ..	322	1,610	1,325	468	123	249	..	840	485	1·5
N ..	200	400	268	97	28	82	..	207	61	·30
O ..	426	3,195	2,827	618	147	1,235	..	2,000	827	1·94
P ..	68	833	742	246	173	110	..	529	213	3·13
Q ..	91	1,665	1,483	326	280	289	318	1,213	280	3·07
R ..	140	4,900	4,620	1,462	820	946	720	3,948	672	4·80
Total	1,247	12,603	11,265	3,217	1,571	2,911	1,038	8,737	2,538	2·21 average

The amount required on Revenue Account to pay 10 per cent. dividend, provide for all expenses of Distribution, Salaries, Office Expenses, Depreciation, Repairs, &c., under normal conditions is £2,400 per annum. It will be seen, therefore, that our balance approaches very near to this figure; but we have now, however, in preparing our estimate, to face one of the periodical advances in price of raw material, which in this case is a natural product. We have therefore, like the Chancellor of the Exchequer, to forecast the consequences of this advance, which in this item alone is estimated to require at least £300 for the year, and to allow some margin, say £350. In addition to this, the price of coal has advanced, and there are not wanting signs that an increase in price of manufacturing coal will take place during the next twelve months. It is, therefore, calculated that a sum of at least £1,200 must be provided as an addition to

costs, of which £600, or about half, may be expected to be repaid by probable advances in the price of the product.

We have, therefore, £2,538 less £600 as our provision towards £2,400, and it is at once evident that some elasticity must be obtained if the required return on capital is to be maintained. This is found in the estimate by an increase in the output of the "R" product. As will be seen from the summary of the three years' sales, this has given a yearly increase, and, after a careful consideration of the various points affecting the output of this and the other products, the output is estimated for the succeeding year on the following basis:—

Table C7.

STANDARD ESTIMATE OF OUTPUT.

Product	Last Year	Highest	Estimated for Year	Gross Profit	Profit
	Tons	Tons	Tons	£	£
M	322	460	370	1·5	550
N	200	200	220	·30	66
O	426	557	460	1·94	892
P	68	69	50	3·13	156
Q	91	174	120	3·07	368
R	140	140	200	4·80	960
Total	1,247	1,600	1,420	2·21 average	£2,992

as against a requirement of £2,400 normal and £600 extraordinary expenditure.

There can be no question that, once the trouble of setting up a standard of output and planning out the operations of the business for the succeeding year is undertaken, the method will not again be departed from. The very considerable convenience of being able to measure month by month the production and the sales, of being able to gauge with the standard the results obtained up to date, and the comparison of the actual prices obtained with those of the estimate, form altogether a most

valuable aid. This aid is as far removed from the rule of thumb method usually in force as this approximate estimate is from the carefully planned standard of output, accompanied with full detail of the cost of production, which is attainable under a proper system of Cost Accounts. The following tables are applicable to industries where there are principal and by-products, and, although the principle is the same, the details are worked out more systematically, and the tables show in full a reconciliation between the standard, the standard revised to the actual production estimate, and the actual results obtained in the carrying out of the production through the year. Wherever there are varying prices, varying quantities, and varying qualities of products it will generally be found to be simpler and more effective to employ a common denominator as a unit, into which all the calculations can be expressed and summarised in small focus. This method, however, has been fully dealt with in the volume on "Multiple Costs," to which the reader is referred.

The formulation of all schemes of cost would, in the writer's opinion, be simplified if their institution were based on the earning power of plant and processes, instead of mere mechanical accounting. This distinction was doubtless present in the mind of a witness before the late Income-tax Commission, when he emphasised the necessity for payment of the tax on the amount divided, as against the basis of the paper profit. The earnings of labour are represented by actual sterling at the end of any given periods, and what labour earns it spends to a very large extent on reproductive energy for the next period.

TABLE C8.

STANDARD OUTPUT SUMMARY AND PRIME COST.

Maximum Standard Effective Output		Revised Standard to Actual Output		Processes	Actual Working			Variation on Revised Standard		
Quantity	Cost Value	Quantity	Cost Value		Quantity	Cost Value	Wages and Process	Quantity	Cost Value	Wages and Process
4,000	336,000	3,000	252,000	Raw Material						
595	24,900	446	18,742	No. 1. Material	420	17,649		−24	−1,093	
	4,800		3,600	Wages			44,50			+850
	48		40	Process Cost			42			+ 2
500	21,000	375	15,750	No. 2. Material	360	15,120		−15	− 530	
	1,200		900	Wages			1,100			+200
	96		72	Process Cost			80			+ 8
350	40,840	263	30,630	P. Material	248	28,860		−15	−1,770	
	8,000		6,000	Wages			7,000			+1,000
	6,000		4,500	Process Cost			5,200			+700
550	60,196	412	45,147	Q. Material	424	46,462		+12	+1,315	
	16,000		12,000	Wages			13,500			+1,500
	4,000		3,000	Process Cost			3,100			+100
920	94,250	690	70,688	R. Material	720	73,761		+30	+3,073	
	14,000		11,500	Wages			12,000			+500
	8,500		6,375	Process Cost			6,480			+105
995	94,271	747	71,041	S. Material	782	74,637		+35	+3,596	
	18,000		13,500	Wages			14,500			+1,000
	7,600		5,700	Process Cost			6,500			+800
90				Shrinkage						
4,000	427,235	3,000	319,185	Totals	3,000	256,589	73,952	+77	+7,984	+6,765
								−56	−3,393	
× 1,000 lb.	Shillings	× 1,000 lb.	Shillings		× 1,000 lb.	Shillings	Shillings	+21	+4,591	

(The values are shillings per 1,000 lb.)

TABLE C9.

STANDARD OUTPUT SUMMARY, PRIME COST AND EXPENSES.

Description	Reference	By-Product No. 1 Value	By-Product No. 2 Value	Product P Value	Product Q Value	Product R Value	Product S Value
Prime Cost :—							
Material	A	17,649	15,120	28,860	46,462	73,761	74,637
Wages	A	4,450	1,100	7,000	13,500	12,000	14,500
Process Cost	A	42	80	5,200	3,100	6,480	6,500
Prime cost total		22,141	16,300	41,060	63,062	92,241	95,637
Direct Cost	D	1,260	6,754	2,240	1,650	1,980	3,125
Indirect Cost	E	2,077	2,446	5,320	6,546	5,927	4,204
Depreciation	D	750	840	1,480	1,310	1,640	1,180
		26,228	26,340	50,100	72,568	101,788	104,146
Quantity in units		420	360	248	424	720	782
Cost per 1,000 lb. = 1 unit		62·44	73·66	202·01	171·15	141·36	133·18
Deduct excess cost due to partial output as follows :—							
Prime Cost	A	2·03	0·57	6·85	3·77	0·84	2·30
Direct	D	0·44	0·58	1·49	0·77	0·57	0·38
Indirect	E	1·23	1·70	5·38	3·85	2·05	1·34
		3·70	2·85	13·72	8·39	3·46	4·02
Standard Cost per unit		58.74	70·81	188·29	162·76	137·90	129·16
Excess Cost as above		3·70	2·85	13·72	8·39	3·46	4·02
Increased price raw material				8·52	8·52	8·52	8·52
Total cost shillings per 1,000 lb.		62·44	73·66	210·53	179·67	149·88	141·70

CHAPTER XIII.

STOCKS AND STOCKTAKING.

THE chapters which have already been devoted to the measurement of solids and liquids contain a variety of points which require to be borne in mind in the stocktaking of chemical industries.

The inevitable necessity of a definite stoppage of the works for repairs and renewals, which should be arranged to synchronise with the annual stocktaking, will considerably simplify the trouble and inconvenience in dealing with inter-departmental measurement of products.

It follows that, in order to avoid delay in delivery, all products are finished, as far as practicable, for market, and the stock, except for season's goods, is therefore heavier as a rule at this period of the year.

Very considerable advantage can be obtained by arranging for stocktaking some two months before the date at which it is to be taken arrives.

In some industries, where there are inter-departmental stocks of considerable bulk in heaps for maturing, arrangements are made fully three months before stocktaking for new deposits to be made, so that there may be an actual enumeration to check with the measurements. In such cases the moisture content is usually a considerable factor in the estimation of the weight.

Cuttings are made at various places in the deposits; samples taken and submitted to the laboratory for estimation of moisture which varied from 25 to 12 per cent., according to the time the deposit had been on hand. In other cases the deposit is so arranged that it can be worked out in time to correct any error in measurement.

Where a proper system of Cost Accounts is instituted the percentage of the actual product present in any interdepartmental stock should be capable of actual demonstration, and the price at which this is taken into stock is, therefore, capable of accurate comparison with the Process Accounts at this stage. This matter is of great importance where estimated stocks are taken for the purpose of periodical Cost Accounts at other dates than that of annual stocktaking.

Speaking broadly, all interdepartmental stocks should verify themselves with the Process Accounts, and be capable of expression in a certain percentage composition of the finished product.

The advantages which occur in stocktaking from the figures disclosed by the Cost Accounts of processes are very considerable, and an immense amount of labour can be saved thereby, with the confidence that the stock will come out at the estimate.

It is, of course, self-evident that the basis on which the stock is taken should be the same at each period. Any allowances or differences should be written off in the Process Accounts themselves as an expense, so as to avoid any interference with the system of percentages, &c.

In the case of most chemical industries, especially in those in which the processes are continuous, there are kept in stock duplicates of machine parts ready prepared in case of breakdowns in machinery; and these are essential, if the continuity of the process is to be efficient.

In many cases these are interchangeable, and are put into work periodically, the worn part being taken out, repaired, and renewed ready to take its place. The general renewal and repairs being undertaken at the time of stocktaking, there is generally a heavy repair stock in hand, if the stocktaking commences with the stoppages. In some cases Christmas, Easter, or August is taken advantage of for this purpose, according to season's requirements. Where this is done the expense of repairs at this juncture is a very heavy one, and the incidence of this requires some carefulness on the part of those responsible for the stock.

Boiler cleaning and repairs at this time add to the bill, and it is no uncommon thing for the expenditure at this time to amount to one-fourth or one-third of the total for the year, if the repairs and renewals are thoroughly carried out.

If the repairing stock is taken at the commencement of the stoppage the spare parts will, or should, be in an efficient condition for replacement. If at the end of the stoppage the spare parts in stock will be considerably inferior in condition, and probably worth considerably less. Some firms adopt the system that all repairs should be made before stock is taken, in which case the cost of repairs, including the labour and material in making good the parts for replacement, falls into the year which is just closing. In other cases it is held that the year having borne the expense of repairing for the renewals and the repairs, the following year takes the cost of the replacement. It will be seen, however, on following the argument to its logical conclusion, that if spare parts are to be included in the stock the effect of any valuation which includes that present condition is to credit the year which is closing in the stock for the expenditure debited in repairs. It would appear desirable therefore that the spare parts in stock should be valued at their worn-out condition.

The point may seem a fine one, but it is capable of making a difference in some repair stocks of some £200 to £300 in the profit dependent on whichever method is adopted.

With regard to finished stock, some authorities would allow of a small deduction from the selling price, on the ground that not only is the stock finished, but that the actual expense of selling has been incurred in the year, and that, save for discount and carriage, the goods are practically worth the sale value, a further consideration being that to a considerable extent the stock will have already been delivered before the stocktaking figures are completed.

It is no uncommon thing to find, even at this date, stocks taken at selling prices, less only some small percentage, and the arguments mentioned above appear to beg the point at issue.

The stocks on hand at the 31st December, say, represent, or should do, their actual condition on that date, and the values at which they are calculated should not carry them beyond that date. Any inflation of that value must necessarily be at the expense of the year next ensuing, and fluctuations of finished stock under such circumstances exercise an effect on the profit for the year which is to be deprecated. With regard to the work in progress, the Process Account should show the cost of the product at the particular stage at which it has been suspended for stocktaking. The proportion of expenses which should be borne by the work in progress is a matter on which widely divergent views are held. In the case of the illustrations in Division 2 of this volume, it will be seen that, with the exception of establishment charges of Rent, Rates and Taxes, General Superintendence, and Office Expenses, the Cost Account for each process includes all manufacturing charges, including Depreciation and Interest on Plant. Whatever basis be adopted, the calculation will be considerably simplified if the percentage

value of the unfinished product to the finished product is taken as a basis for the allocation of expenses. Presuming that rex sulphate at any particular stage represents 25 per cent. of the cost of the finished article, then this proportion of the general expenses is applicable.

One of the points which may arise in connection with stocks is the method of dealing with any quantity of raw material on hand, which is either accumulated by reason of changes of markets or through failure of contracts. It is not altogether uncommon to find some quantity of raw material on hand which has been held in stock for more than one year, and which, owing to changes in process of manufacture, or from changes in the trades specially catered for, is not now required. "Hope springs eternal in the human breast," especially at times of stocktaking. This may be looked for in either raw material or process material, and it will be well, therefore, in considering the Process Cost Accounts in relation to stocktaking to see that the constituent percentages for all materials are clearly expressed in the Stock List, and a comparison of these should be made with the Weekly Material Sheets to see that the materials are being actually used and will be of service. Another valuable point in Process Cost Accounts as regards stocktaking is the possibility of verifying the stock on hand by the special Ledger Accounts open in the Costs Ledger for each process material. This should prove of considerable service in detecting leakage, and where any process material is used for more than one department special Controlling Accounts for such material should be raised in the Cost Ledger.

In the case of chemical industries the arrangement of stock is necessarily somewhat primitive. Process material is usually kept in the particular building where it is to be used, and raw material usually bulks too large to be subjected to such arrangements as to stock-keeping as are possible in the engineering

trade. On the other hand, both are usually well separated in strictly defined limits, and, as such, a comparison is readily made with the Stock Sheets of the previous year. For instance, if in the Maceration Department peroxide of hydrogen is used, the whole of the stock would be probably attached to that department, and within ordinary limits the stock should not vary particularly, and should be readily verified with the balance shown in the special Ledger Account under that heading. The same remark applies to all other process material.

CHAPTER XIV.

STEAM POWER AND COAL.

THERE is perhaps no more important item in the cost of processes than that of steam, whether used for purposes of power or for heat. It is, however, in connection with one particular phase of this subject that we are interested in this connection, and that one of economy.

The production of steam by the most economical method is a matter for the engineer, but the effects of the method adopted is one that affects considerably the cost of the process.

The true test of economical steam production is the quantity of coal required to evaporate water into steam. The results obtained differ very considerably, as may be expected from the great variety of boilers and other circumstances connected with steam generation.

Six pounds of water evaporated per pound of coal consumed may be taken as a general average of moderate working. Good working would put this at seven pounds of water per pound of coal.

Record of trials may be found in most text-books on steam, and the following have been selected for illustration:—

Galloway Boiler	7 lbs.	of water per lb. of coal.
Babcock & Wilson Tubular	6½ lbs.	,, ,, ,,
Lancashire Boiler	6 lbs.	,, ,, ,,

With the addition of Green's Economiser, which is a series of upright tubes *through* which the feed water is circulated on its way to the boiler, and *round* which the waste gases from the

boilers are passed on their way to the chimney, the results were increased to 8½ lbs. of water per pound of coal.

In many cases the economy of steam production is largely dependent, in the first place, on the pressure at which the steam is generated; and, secondly, on the sufficiency of the boiler capacity.

One of the principal difficulties to be met with in this factor of our cost is the apportionment of the expense under this head as between departments and the further division between heat and power, and the apportionment of the results as between different stages of the process.

For this purpose we require the data of the heating up of the materials. Suppose we have a vessel containing, say, 1,000 gallons of water, or other liquid, at, say, 60 degrees Fahr., and this requires to be heated up to 150 degrees Fahr. This will occur, say, six times per twelve hours five days per week. We have, therefore, 1,000 gallons × 30 times × 90 degrees Fahr.

It is probable that, taking the usual quality of coal used in chemical process works, about 11,000 British thermal units may be taken as the average value of "slacks," while 12,000 to 15,000 will represent the value of the better qualities of coal. 1,000 × gallons × 10 lbs. per gallon × 30 = 30,000 lbs. × 90 degrees units = 2,700,000 units. The latent heat of steam may be taken at 1,000 units, which gives us 2,700 lbs. of steam to be used in the operations.

Taking 6 lbs. of water for 1 lb. of coal we get 4,500 lbs. of coal as the value of the heat required, or practically two tons.

In most chemical works the steam is common for both process and power, and the apportionment of these charges is a complicated matter, or at least it is generally made to appear so.

There is, however, little difficulty in obtaining the total cost of steam production if it is actually required.

It is impossible in the space of a chapter to give detailed results of trials, and for full particulars of these the reader is referred to the many text-books on steam. An examination of recorded trials gives the following data, which may be taken as a practical costing on a medium capacity plant.

	Per 1,000 gallons of Water Evaporated. £ s d
Cost of Coal	0 6 7
Wages	0 0 5·51
Repairs and Maintenance	0 0 1·28
Depreciation Plant and Buildings :—	
At 2% on £548	0 0 2·52
At 5% on £1,733	
Sundry Expenses Lighting	0 0 1·76
Cost of Water (if any) to be added ..	0 7 6·07

The following are examples of two samples of Engine Slack, South Yorkshire Seam :—

No. 1 Sample.

Moisture..	9·38%
Volatile Matter	28·62
Fixed Carbon	50·50
Ash	11·50
	100·00%

Calculated Calorific Power equals 10,972 British Thermal Units.

No. 2 Sample.

Moisture..	8·96%
Volatile Matter	29·74
Fixed Carbon	54·00
Ash	7·30
	100·00%

Calculated Calorific Power equals 11,623 British Thermal Units.

The total cost of a 30 inch by 8 inch Lancashire boiler, including excavation and brickwork fixed complete, will vary in the cost of the boiler, but may be put down at £450 to £500, while the main flue and chimney, to serve, say, four boilers, would require a sum of £375 to £425, according to height of chimney.

Although perhaps steam production in chemical works is at its lowest point of efficiency, it is possible to obtain the indicated horse-power of the engines for the purpose of apportionment of cost of steam.

The quantity of coal used per indicated horse-power per hour varies largely, according to the class of engine used, and where many pumps are in operation, steam driven, special allowance must be made for these.

Lbs. of Coal per indicated Horse Power	*Variation*
Non-condensing Single Cylinder Engines	6 to 12 lbs. Coal
Compound Condensing Engine, two Cylinders	3 ,, 5 ,,
Pumps, steam driven (good)	7 ,, 9 ,,
,, ,, (medium) ..	15 ,, 24 ,,

An approximation of the number of hours run, and the average indicated horse-power according to the load, will, with the prior information, give the basis for the apportionment of the cost of steam production as between power and process, and this can be localised further according to the special circumstances once the data are laid down.

The apportionment of the coal and power charges may appear to present some difficulty in cases where the output is fluctuating, and in some periods may reach the maximum and in other periods the minimum. This, however, may readily be avoided, as in any case the output is an established basis for calculation, and, therefore, in extreme cases only would this be in question.

It will be noticed that in the Coal and Power Charges Account there is a proportion to General Charges, which is in respect of heating for offices and stores. No good purpose would be served by the inclusion of rent, or other fixed charges, as in process costs there is necessarily a balance on each process available to meet general charges. Not only so, but the capacity of the buildings occupied by any particular process is necessarily an incident of the general fixed charges, and the prices as between departments cannot include profits on each process; it follows, therefore, that no general charges against general profits require to be taken into account.

The principal benefit to be derived from a division of cost under different processes is primarily to induce efforts at economy, as it necessarily follows that if we take, for instance, concentration process either in rex sulphate or beet sugar production we have in this process the greatest proportion of the total cost, and consequently the item in which economy is essential if the general cost of production is to be lowered.

In like measure the preparation of the Cost Accounts under the heading of the processes does lead to improvements in results, brought about principally by the realisation of the high proportion to the general cost borne by any particular process.

Once a ratio of costs is obtained it is easy for the management to realise the incidence of the cost of each process to the total cost of production.

Unfortunately, it is too often the case that the absence of this knowledge leads to processes being continued long after their economic efficiency has departed, and, had the attention of the management been directed by a proper system of costs, the matter would have received due consideration earlier.

Coal and Power Charges Account.—

For the convenience in reference the Coal and Power Charges Account is here illustrated, showing the table of factors from which the same is prepared. The table gives the units under the different heads of Pumping, Heating, and Power, and the incidence is fairly illustrative of the actual conditions to be met with in actual working.

The units are prepared from Weekly Output Sheets, and this is made up from a chart giving the proportions under different weekly outputs.

In the case in question there was a steady maximum output during the whole of the period. In other cases there might be a much larger balance to fall to General Charges, being in respect of the expenditure in weeks unproductive, or where the full economic production had not been reached. The system thus provides a ready means of appreciating the increased ratio of establishment charges due to diminished output.

COAL AND POWER ACCOUNT.

	£	s	d		£	s	d
To Stock on hand	323	5	2	By Steam and Power Units Provided as follows—			
„ 1,523 tons Coal, 14s. ..	1,066	5	0	Lixiviation	220	6	0
„ Cartage of Coal, 6d. ..	38	1	6	Reduction	31	1	8
„ Wages, Stokers	134	1	8	Concentration.. ..	1,218	15	7
„ Water Charges	53	2	6	Crystallisation ..	40	7	0
„ Light	31	2	3	Crude	76	2	2
„ Oil, Stores, Packing ..	14	11	9	Purification	13	9	9
„ Repairs, Maintenance ..	131	2	4	Recrystallisation A ..	6	4	5
„ Depreciation	127	10	6	„ B ..	8	8	11
„ Interest on Plant	84	6	3	„ C ..	10	1	9
				General Charges ..	32	9	0
				Stock at End	346	2	8
	£2,003	8	11		£2,003	8	11

PROCESS COSTS.

TABLE OF FACTORS FOR APPORTIONMENT OF COAL AND POWER CHARGES.

	Units Pumping	Units Heating	Units Power	Total Units	Rate	Charges
						£ s d
Lixiviation	46·2	90·5	51·1	187·8		220 6 0
Reduction	12·2	14·3		26·5		31 1 8
Concentration	18 6	924·2	96·3	1,039·1		1,218 15 7
Crystallisation	24·8	9·6		34·4		40 7 0
Crude	12·4	4·6	48·6	65·6	23/5½	76 2 2
Purification	6·2	5·3		11·5		13 9 9
Recrystallisation A ..	3·2	2·1		5·3		6 4 5
,, B ..	3·6	3·6		7·2		8 8 11
,, C ..	4·8	3·6		8·6		10 1 9
	132·0	1,058·0	196·0	1,386·0		£1,624 17 3

COAL AND POWER ACCOUNT.

Lighting.—

Where gas is the illuminant employed the provision of separate meters for departmental consumption should be rigorously insisted upon. The hire of a few meters at the low rental at which these can be obtained from the gas suppliers will be amply repaid by the check thus secured on the consumption of the various departments, in addition to which it provides a good internal check upon the main supply meters, and the basis of the departmental charge.

If the foreman is made to furnish on his weekly report the index reading of his meter, and to put down the consumption in plain figures, it will not be long before the excess and waste in this direction is modified.

The same remarks apply to electric lighting. In this case the meters are somewhat more expensive, and if the current is home-made it may be necessary to purchase these. At the same time, the investment will generally show a higher rate of return than the capital employed in manufacturing, in addition to which the gas generally makes its presence known, whereas leakages of

current have an unwholesome habit of damaging plant, &c., and being a steady loss it is not usually perceived.

In connection with dynamo insurance the electric light installation may be tested periodically for a small premium, which is amply repaid by the greater security and by the lessened cost of this branch of expenditure.

POINTS ON COAL AND POWER ACCOUNT.

One-eighth of an inch deposit of soot renders the heating surface practically useless.

One-sixteenth of an inch of scale or sediment will cause a loss of 12 per cent. in fuel.

A loss of 21 per cent. in boiler efficiency has been known to be due to bad setting.

Differences in the method of firing may produce a loss of 13 per cent. in economy.

A first-class boiler will give 10,000 heat units per lb. of coal burnt.

The best record is 1½ lbs. of coal per horse power per hour in first-class engines.

An average steam engine will use 3½ lbs. of coal per horse power per hour, which is equal to a loss of 93 per cent. of the force delivered to it.

Most of the excessive coal consumption is due to cheap boilers, cheap engines, and cheap labour.

Standard consumption is equal to 30 lbs. of water per hour evaporated at 70 lbs. pressure from 100 degrees for each horse power.

One horse power will, under ordinary conditions, heat approximately 7,000 to 10,000 cubic feet in brick factories, mills, &c.

CHAPTER XV.

DEPRECIATION.

THE factors involved in the consideration of depreciation of chemical and process plant are perhaps more accentuated than any other form of accounts, and the extent to which depreciation should be included as part of the process cost is a burning question.

Like many other questions, this has suffered by the zeal of the advocates who have obscured the real points at issue.

The shortness of the period during which, by the nature of the materials, the plant can be maintained in original efficiency differs with every individual product. Changes of process and alterations in markets give a different, but also intensified, effect.

In any case, the considerations on which advocates of depreciation being taken as an establishment charge base their claim are non-existent in the case of process plant, and in the author's opinion depreciation must, by reason of the circumstances, in this case be taken as part of process cost.

The subject divides itself naturally under three heads:—

Depreciation as affecting Buildings.

Depreciation as affecting Fixed Plant.

Depreciation as affecting Loose Tools and Utensils.

Depreciation of Buildings.—

One of the principal factors generally overlooked is the absence of any strict dividing line between what is generally included as buildings, and what is regarded as fixed plant.

In many cases the building is merely a shelter, and the girders and columns on which the shelter is raised and supported *exist primarily for the purpose of the plant, and not for the building.*

The provision of floors, or what do duty as such, depends altogether on the disposition of the plant, and changes in process or in plant may, and do, lead to the omission, or to the erection or replacement, of floors at other levels than at first contemplated or erected.

It follows, therefore, that buildings should receive some consideration in regard to depreciation from the point of process cost, and this from a point of view altogether separate and distinct from the maintenance of markets or changes in manufacture, which may be taken into account in the distribution of profits.

Having regard to the general character of buildings in chemical works, and the deterioration in character inseparable from processes and materials, a charge of 2 per cent. per annum as a factor in process cost does not appear unfair or excessive, and in the costings referred to in the previous section of the book this basis has been adopted.

The subject of depreciation of plant is one to which increasing attention is now being paid, and there is, perhaps, no section of trade to which it appeals more forcibly than that of chemical industries. It is a subject, moreover, which, while generally accepted in principle, has given rise to great divergence of opinion in details. Some considerable confusion exists through a want of clearness in definition, and it is well, therefore, to

clearly define, in the first place, what is intended to be covered by the words "Depreciation of Plant."

It is now generally recognised that the wastage of capital invested in plant and machinery is as much a working expense as the labour which operates it, and forms an equally definite part of the cost of production. It is also recognised that this wastage proceeds from a variety of causes, differing in effect. We may enumerate these as follows:—

Wastage by Deterioration.—

A machine or plant may be renewed and repaired in part, and may be made practically efficient in working, but there is a slow inevitable depreciation taking place, which, sooner or later, extinguishes the value.

Wastage by Obsolescence.—

Under this head the plant or machinery may be rendered obsolete by reason of its supersession by an improved type of machine, or partially in the reduction of the price after purchase, or by scientific discovery, which may render the whole or any part of a plant obsolete, owing to changes in process or manufacture. This wastage is practically final in effect.

The term "depreciation" is also used to cover an annual provision in anticipation of the expense of the renewal of the machinery and plant at some future period. Some authorities would carry the matter still further, and include under the head of depreciation a provision against the possible diminished value of the plant and machinery, which may occur by reason of the changes in markets and trades. In some cases the life of machinery and plant may be dependent on the period of a patent. These, however, are matters which are, perhaps, more properly dealt with in the light of reserves, to be provided for

before the distribution of profits, and are not risks which solely affect the plant, but also the other items of a Balance Sheet.

We have, therefore, to consider an annual charge for depreciation to provide for (1) Deterioration, (2) Renewals, (3) Obsolescence, and I purpose dealing here with the subject of depreciation under these heads as affecting cost of production.

With regard to the two primary heads of Deterioration and Obsolescence, we may describe the effect of these on the life of the plant as—Deterioration, death from natural causes; Obsolescence, accidental death.

The illustration is, perhaps, homely, but if you will consider it in the light of insurance you will more readily appreciate the difference in the risks and the annual premium involved therein.

Residual Value.—

In dealing with the estimated life of plant and machinery we have to take into account the residual value of the machinery or plant when its period of usefulness has expired; and in dealing with plant of a special nature it may be generally assumed that, in proportion to its special character, its residual value will be low. In plant of a general character, as engines, boilers, shafting, pulleys, &c., in the event of displacement its residual value will be comparatively high.

Method.—

In like manner, when we come to deal with the plant as a whole for the purpose of assessing the annual provision for depreciation, we find that the considerations affecting deterioration, renewals, and obsolescence differ greatly according to the character of the plant.

There are two extreme methods of valuation:—

(1) The method of assuming an average percentage rate covering the whole plant of, say, 5 to 7½ per cent. on the book value.

(2) The individual valuation of each machine, and the writing off of the differences in value on each.

Both these methods are faulty. In the first method the result is hazardous, as the percentage may be assumed on a proportion of general and special plant which may vary considerably afterwards. In the second place, the detail is very considerable. It has to be done at a time of pressure, and, if left to other hands than that of a principal, the results are generally too favourable.

In arriving at a basis, therefore, for the settlement of a depreciation charge it will be found generally desirable to classify the plant, and by taking the plant and machinery in each department, and abstracting the items of each under five or six classes, we shall get, in the first place, a departmental separation; and, secondly, a classification under each department of, say:—

Motive Power: Boilers, engines, &c.

Prime Movers: Shafting, pulleys, and transmitters.

Process Plant: Fixed, wearable, loose.

Accessory: Railway trucks, weighing-machines, travellers, cranes, and the like.

By leaving space in each department inventory we can provide for additions, and by having loose sheets with additional columns for abstracting we can economise in re-writing.

Having obtained our totals thus, we can then apply to each department and subdivision a rate in respect of deterioration, obsolescence, and renewals, based on our experience. The particulars thus obtained will also afford a basis for the charges in our Costs Sheets, as we shall thus obtain a departmental depreciation charge. We can then adopt a fixed rate on this basis.

Life of Machinery and Plant.—

In considering the question of the rate at which depreciation of plant and machinery should be provided, the deterioration of the same by reason of the destructive character of the materials is not the only factor. The contamination of the products resulting therefrom may, and does, render the life of the plant more precarious than in the case of other industries.

The introduction of enamelled plant as against the wear and tear of acids has been only partially successful, and the renewal of these portions of the plant requires to be kept steadily in view in regard to the depreciation of plant rates. In the case of all chemical and food processes it is not only the actual wear and tear of the plant which requires to be taken into consideration, but the liability of the plant, when worn, to deteriorate, or to affect injuriously the products which are being subject to treatment therein.

Depreciation Account.—

	Balance at previous Stocktaking			Depreciation.		
	£	s	d	£	s	d
Mineral Extraction Plant	440	0	0	22	0	0
Lixiviation ,, ...	1,236	0	0	61	16	0
Reduction ,, ...	286	0	0	21	8	0
Concentration ,, ...	2,836	0	0	614	18	4
Crystallisation ,, ...	527	0	0	26	7	0
Purification ,, ...	298	0	0	14	18	0
Crude Alum ,, ...	329	0	0	16	9	0
Recrystalling ,, A., B., and C.	694	0	0	69	8	0
Steam Power and Coal Account ..	1,098	0	0	127	10	6
	£7,744	0	0	£974	14	10

The foregoing Account for Depreciation of Plant shows the working out of the depreciation on the special plant of each department, and these charges are carried forward to the Process Cost Accounts.

It may be noticed that the concentration plant receives a very heavy percentage as compared with the others, and this is due to the special nature of the plant involved. It will also be

noticed in passing that the division of the process cost brought out here in respect of the depreciation follows the important relation that this department bears to the whole. In this case the repairs are very heavy, and the renewals are practically due every five years in respect of the greater portion of the concentrating plant.

Diminishing Value.—

Before we can proceed to establish a percentage rate on these classes of plant we must settle the basis on which the rates are to be calculated.

For some years the basis of the diminished value obtained by the writing off of the annual depreciation charges has been generally adopted, but during the last few years there has been a tendency to revert to the basis of original cost. For instance, a rate of 10 per cent. on the original cost will exhaust the value in ten annual instalments, but a rate of about 16½ per cent. would be required to exhaust the value in the ten years, if calculated on the diminishing value remaining after the deduction of depreciation in each year.

The argument in favour of basing the calculation on the diminishing value is that the sums written off in the earlier years were greater when the repairs were small, and that this tended to equalise matters. Too often, however, the two factors of rate and basis have not been settled together, and in consequence the adoption of the basis of diminishing value has had the effect of leaving a considerable value in the books when the plant has disappeared.

BASIS OF CALCULATION.

Plant Capital Account, Diminishing Value, and Original Cost.—

The treatment of depreciation of process plant, and also of all plant, is, in the writer's opinion, simplified considerably if the basis of the calculation on the original cost is retained. In all

works which have been in existence some years, and in which renewals and additions to plant have been made, and old plant has been scrapped, it is a matter of much difficulty to dissect out the actual condition of the Plant Account. It has been stated by some authority that the retention of the basis of original cost involves the writing off of the annual depreciation charge to a Reserve Account; but, even if this method is adopted, it is not necessary that any alteration should be made in the usual method of stating this item in the Balance Sheet. For instance, take the following *pro formâ* Plant Accounts in the Private Ledger.

	Dr. £ s d	
Plant Account	61,209 12 6	representing original cost.
Plant Addition Account	8,649 13 4	,, ,, ,,

	Dr. £ s d		*Cr.* £ s d
Plant Renewal Account	11,864 12 3	..	13,200 17 9
Balance	1,336 5 6		
	£13,200 17 9		£13,200 17 9

Representing on the credit side the provisions made for the renewals and on the debit side the expenditure thereon.

Depreciation Account £15,563 18 2

There does not appear to be any difficulty in bringing these figures together to form the usual statement as follows:—

PLANT ACCOUNT.

£ s d		£ s d
61,209 12 6		15,563 18 2
8,649 13 4		1,336 5 6
	Balance ..	52,689 2 2
£69,859 5 10		£69,589 5 10

BALANCE SHEET STATEMENT.

	£ s d	£ s d
Plant as per last Account ..	52,689 2 2	
Added during year	2,325 6 8	
		55,014 8 10
Deduct Sales	529 13 4	
Depreciation ..	3,479 9 4	
		4,009 2 8
		£51,005 6 2

CHAPTER XVI.

DIAGRAMS AND CHARTS.

THE assistance which may be rendered in connection with process accounting by charts and diagrams belongs primarily to the Control Department rather than that of Accounting. In grasping, however, the fundamental movements of materials and products through a series of process stages considerable assistance may be obtained by charting these movements, and there is no system which will express so clearly the factory routine in dealing with the various stages of manufacture as that of diagrams or charts.

In "Factory Management," by Arnold, there will be found a series of charts by which the organisation of the departmental executive is expressed, and by which not only the duties, but the relations and responsibilities of various departments are shown clearly and concisely.

In "Commercial Management of Engineering Works," by Burton, the use of diagrams as recording the movement of earnings, wages, and production over a series of years is dealt with, and reference is made to a lecture read before the Institution of Mechanical Engineers, in which the use of diagrams was illustrated.

Mr. Slater Lewis, in his work entitled "The Commercial Organisation of Factories," devotes a chapter to the consideration of diagrams and curves, illustrated by examples of prime cost and selling prices, together with charts of the principal factors in the Manufacturing and Trading Accounts.

In the "Complete Cost Keeper," by Arnold, there is a chapter on graphic exhibits, which includes some examples of

fuel consumption statistics, which are both interesting and instructive.

In the Journal of the Institute of Actuaries, and also in the Transactions of the Institute of Mechanical Engineers, the use of diagrams and charts is made the medium of effective illustration.

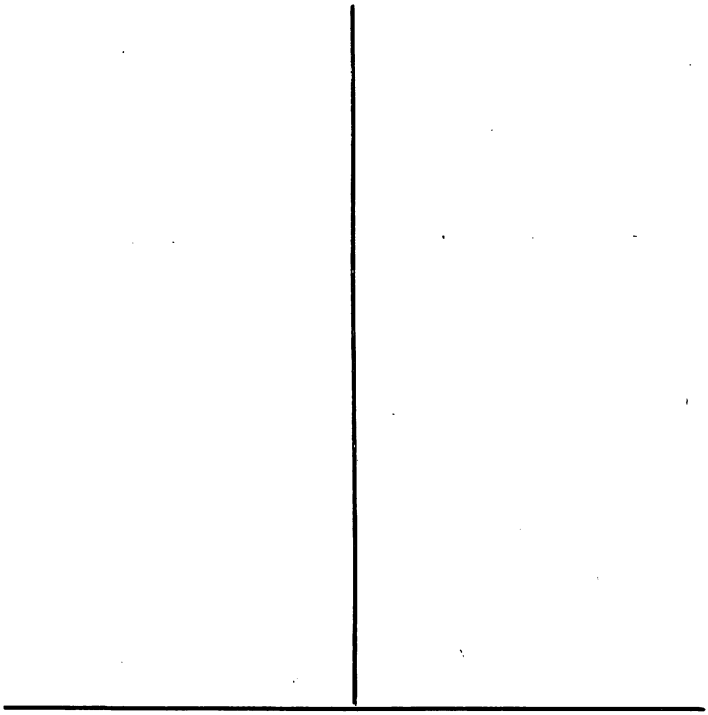
The various statistical articles appearing in the magazines and journals from the pen of Mr. Holt Schooling contain a number of different forms of diagrams, and of late years have shown a considerable advance, from an accounting point of view, in the manipulation of minus quantities.

The use of "graphs" in teaching mathematics is now a recognised method in schools, and their development may in consequence receive a very considerable impetus in the near future.

With regard to the benefit to be derived from an extended use of the diagram and chart in accounting, we must recognise the somewhat narrow limitations which exist in their expression.

In the first place, they can, and do, give us lines of intervening probabilities carried from two extreme points. Given a definite maximum and minimum, they will express the mathematical probabilities of experience between these points, assuming that the same ratio, which is inevitably one of average, will be continued. So far, therefore, they may be used with advantage in estimating the effects of fluctuations in outputs and productive expenses. The graphic effect of display is necessarily greater to visual conception than can be carried by any massing of figures to the eye or to the mind, and therefore it is necessary to bear in mind exactly what this effect is in relation to actual conditions.

The visual conception of height is notoriously inaccurate as compared with that of width, and in consequence the actual relative impression carried by visual conception is about 15 per cent. in favour of height. Note the following illustration of this effect.



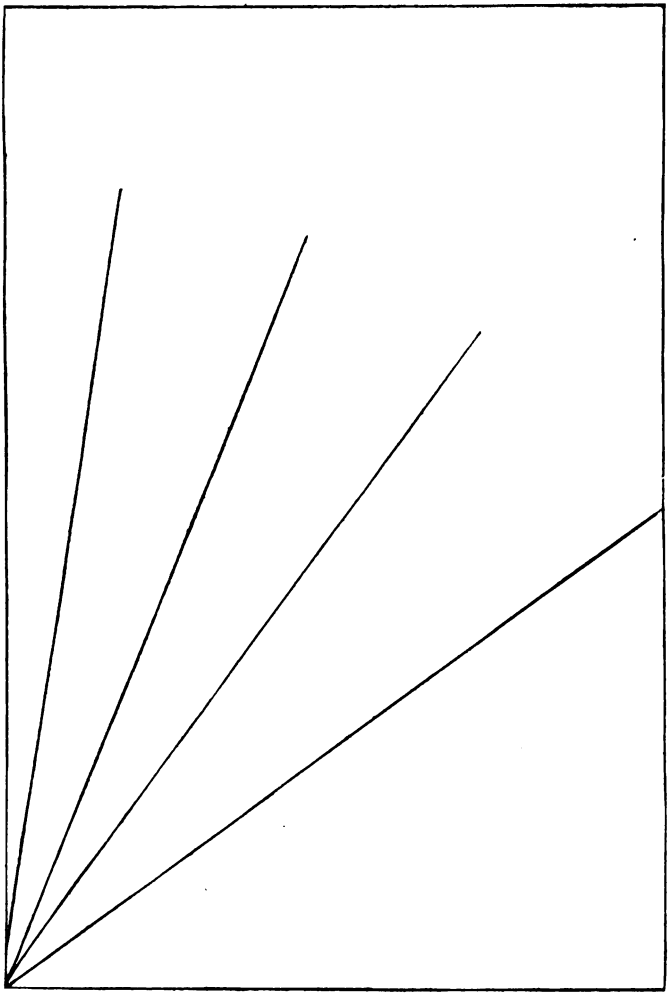
Both these lines are identical in length.

We can therefore anticipate that an exaggeration of effect takes place in all diagrams which express factors of even magnitude in height as against width. Against this effect we have as a contra influence the factor that the height and width in most diagrams represent dissimilar factors, and we may in the case of the height represent sterling and in the width time by periods. The effectiveness of a diagram or chart is in direct ratio with its simplicity. Nevertheless, to maintain this simplicity we must sacrifice comparison in volume. We must either be content to allow our diagram to represent only two primary factors, or, at the best, a secondary factor or zero or dead line as the third factor, or we complicate our diagram and spoil its visual effect by the inclusion of more than one curve.

We may now pass to a consideration of the various forms of diagrams and charts, and their comparative facility in giving expression to accounting illustration.

It is essential, in the first place, to clearly define these requirements, and we may classify these as follows:—

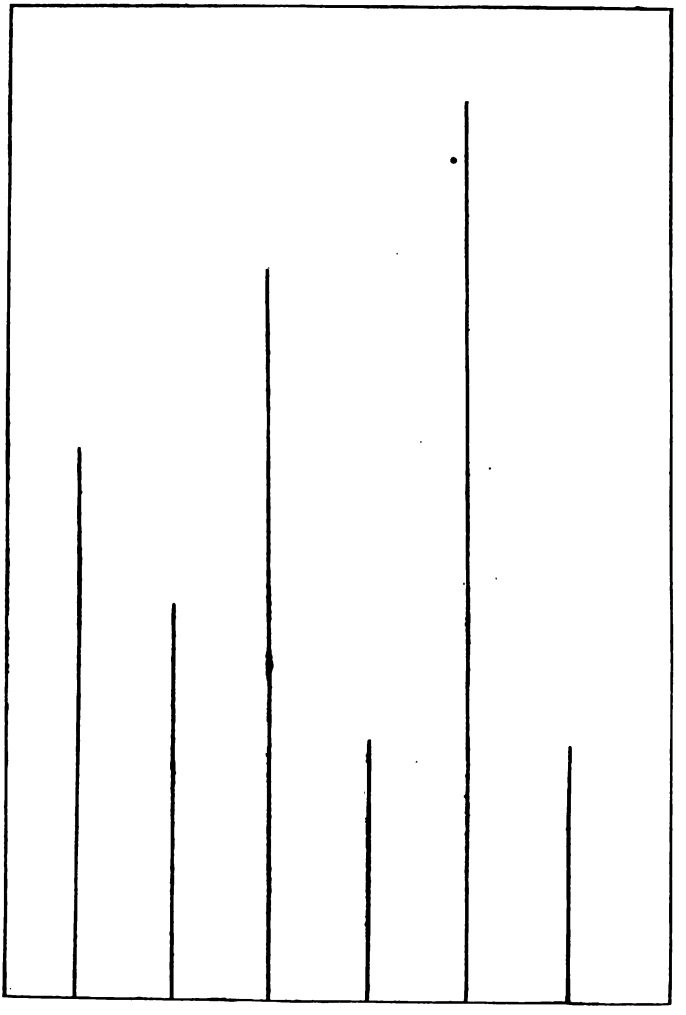
DIAGRAM 1.—LINES OF MOVEMENT, SINGLE EFFECT.



The prevailing expression obtained in this form represents experience as intensification of degree. Here visual exaggeration occurs, as may be seen from the illustration. The exaggeration of effect increases as the lines approach the vertical position from the horizontal.

2. *Fluctuaiion of Result.*—Here we have the experience of completed movement embodied in expression of results.

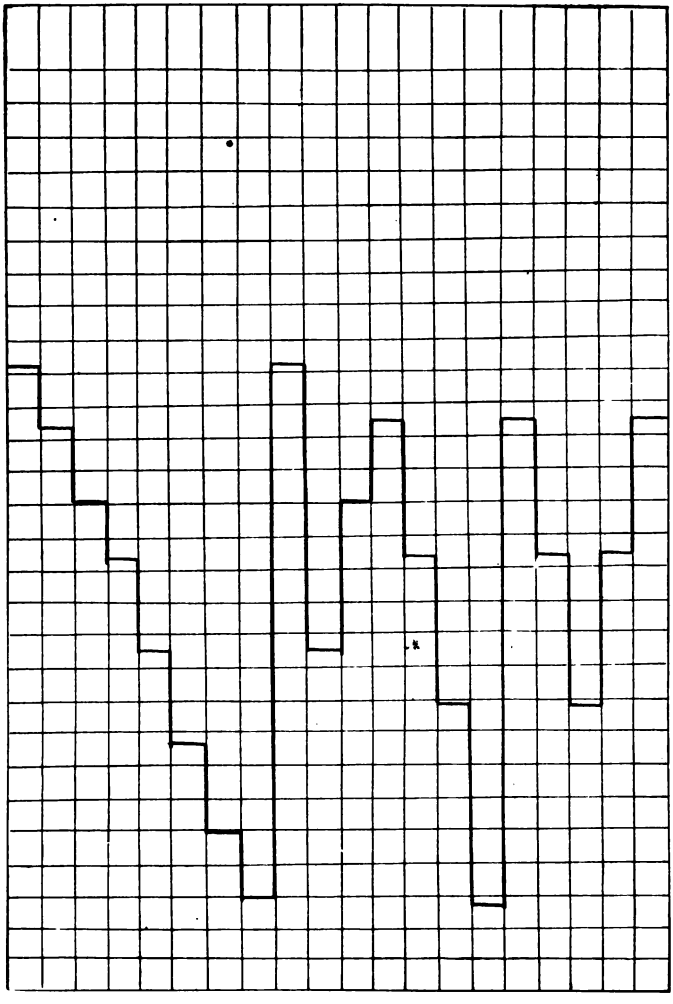
FLUCTUATION OF RESULT No. 2.—TERMINAL EFFECT.



The expression of the fluctuation of result in this form may embody in its experience a considerable group of factors, or, in the alternative, periodic intervals of one factor experience. The grouping of either set of factors is clear and distinct.

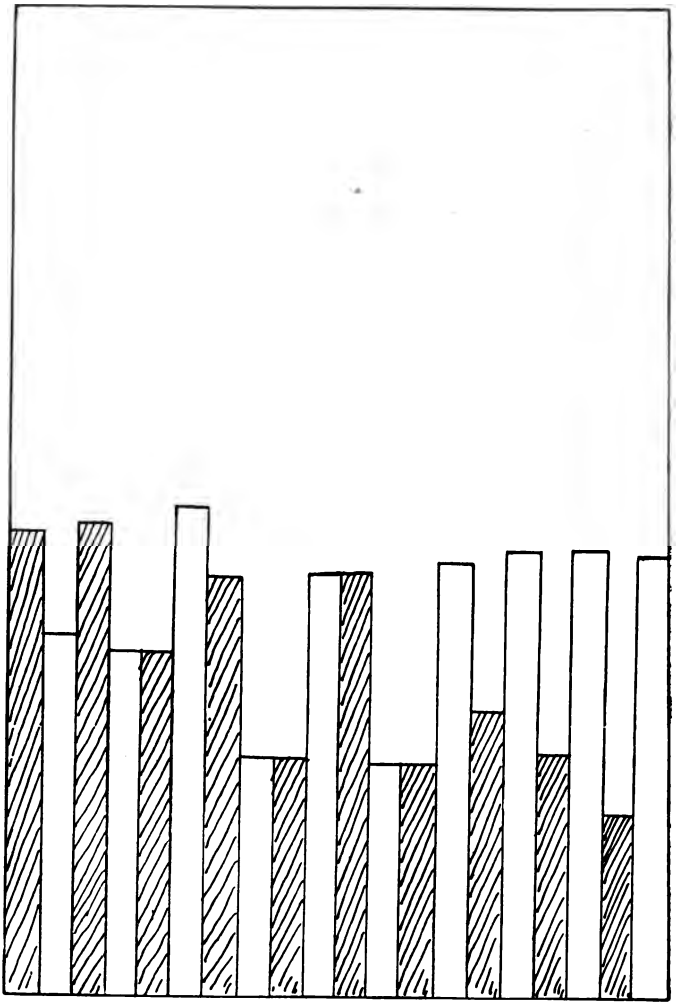
3. *Fluctuation of Result.*—This form is a combination of the two previous examples, and is noticeable especially for the expression of the measurement of the variations. The connecting link between the results emphasises the amount of difference.

FLUCTUATION OF RESULT No. 3.—STEP EFFECT.



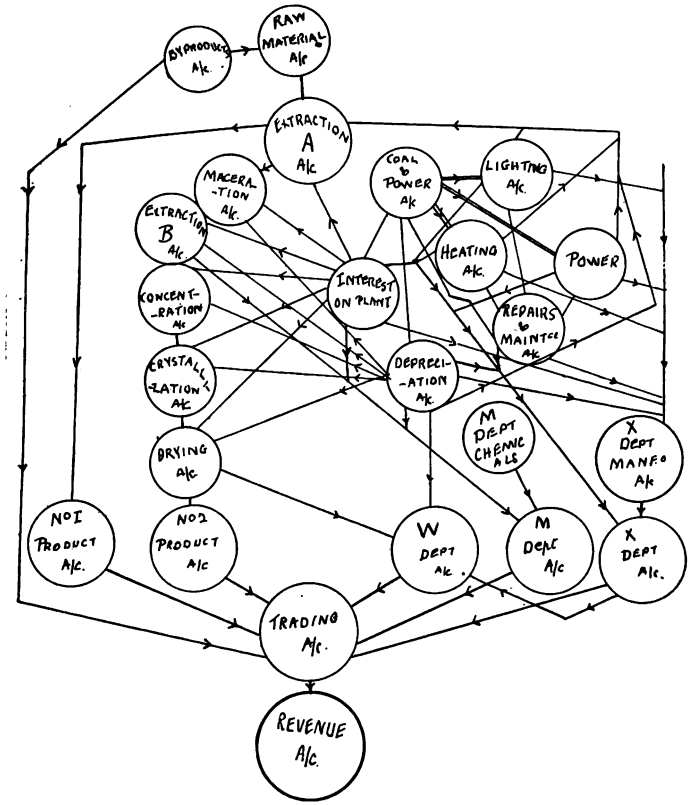
4. It will be seen that as soon as we depart from the simpler forms of diagram the visual conception is complicated and modified. The following form shows a combination of Nos. 2 and 3 forms, and the extent of the loss of expression will be clearly comprehended from the example.

FLUCTUATION OF RESULT No. 4.—COMBINED EFFECT, 2 and 3.

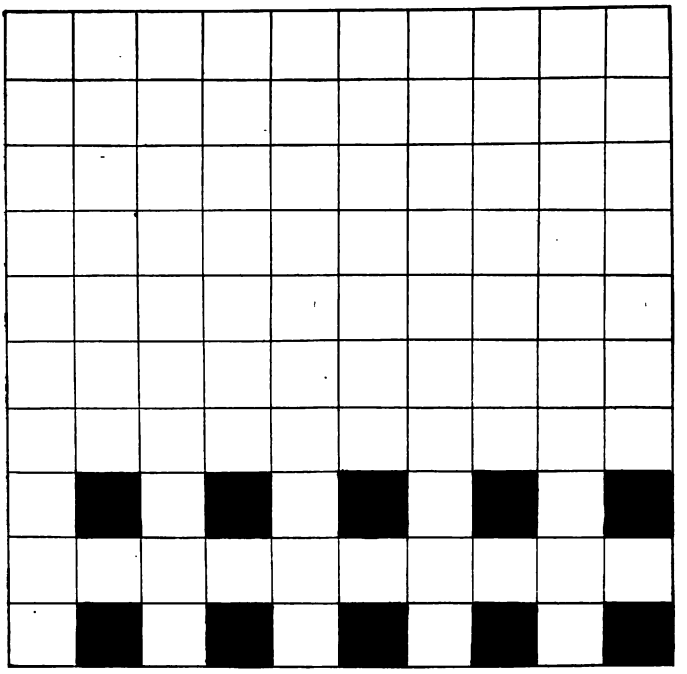


The effectiveness of this example is spoilt by the alternating of the high and low fluctuations of the shaded columns. Had the two factors run on proportional lines the shaded columns would have appeared much more effective.

5. *Grouped Charts.*—The examples quoted in "Commercial Organisation of Factories" are especially valuable as illustrations of this form. The following group chart refers to the Cost Grouping No. 2, but is only carried to such a point in connection as will serve to show the beginning of the complications.



7.—PERCENTAGE DIAGRAM.



TEN PER CENT.

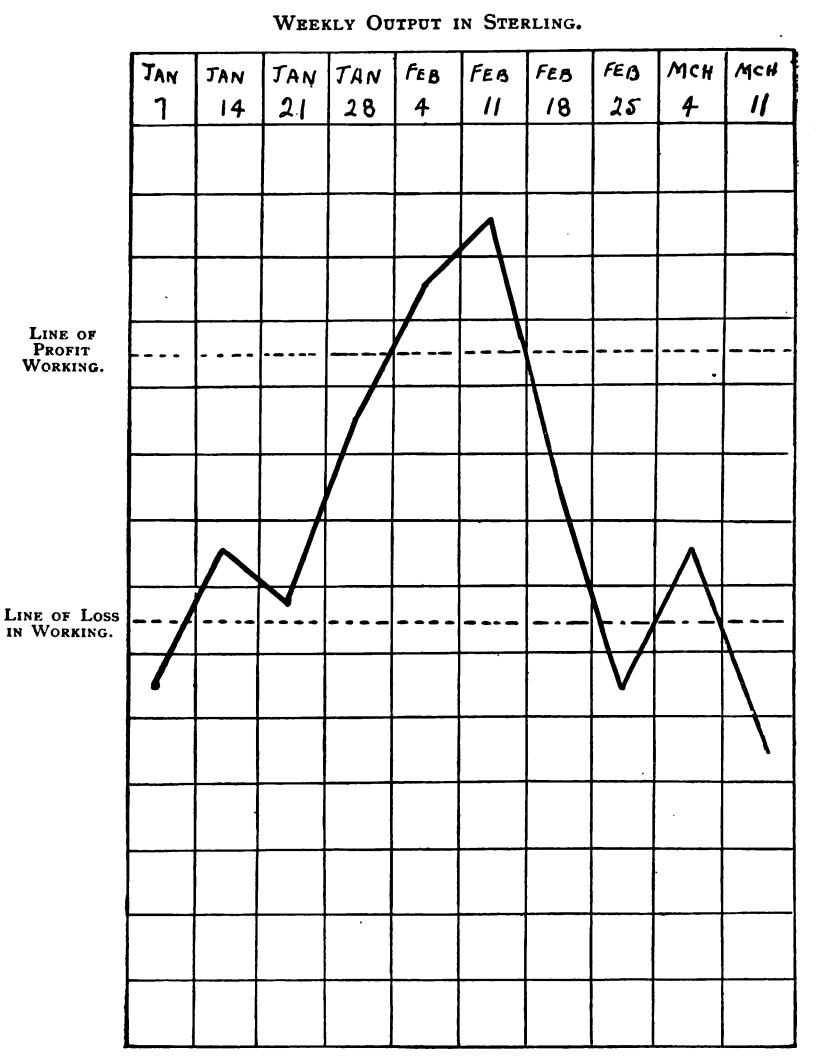
8. There are in addition to these the many fanciful forms which have been evolved as graphic representations, more from the point of view of their striking than of their accurate character.

Of these the circle, the fan, the balance, the weights, and many other forms may be utilised when it is sought to bring out some striking fact to a popular audience, but they are not suitable for our purposes.

Having dealt with the principal forms of diagrams, we now pass to the illustration of some of the best examples of diagrammatic expression.

Output Fluctuations and Holidays.—

Diagram showing the effect of output and holidays on expenses and profits.



The foregoing is one of the best illustrations met with in the expression of the effect of diminished output on the profitable working of a foundry business. It shows in a very suggestive form the necessity of maintaining a full output. Given a cumulative weekly statement, as shown in the Cost Grouping No. 2 section, it emphasises and fixes on the attention the warnings which could not be expressed in a mass of figures. Where an average would conceal the true effect of the working, this illustration shows in a concrete form the deficiency in output and the weeks in which the same occurred better than any figure comparison.

Having touched on the advantages, we must recognise the limitations of the diagram. In the first place, it does not give the cumulative effect of the fluctuations. It only explains these. Secondly, it does not express the component elements of the output; it only aggregates them. We come, therefore, to the point, as in all diagrams, that while fixing the attention on the weakness of any set of figures it is only an extra method of visual appreciation of fluctuation of results. In addition, however, to the expression of results, it gives the line of movement. In connection with the latter we have to consider the point of periodic effect, and in order to appreciate this the monthly figures of the same output are shown in the following diagram. A comparison of these will serve to illustrate the very great care which requires to be exercised in deciding on the period of movement through which the expression is to denote the experience, and under this head there are a variety of considerations to be borne in mind. Too often the period of movement is governed by the question of available space. In the case of all diagrams this is an important factor. In this case the scale is governed by the size of the page on which this diagram will be printed, and while this of necessity does govern the setting out it will be readily understood that it may altogether mar the effect sought for.

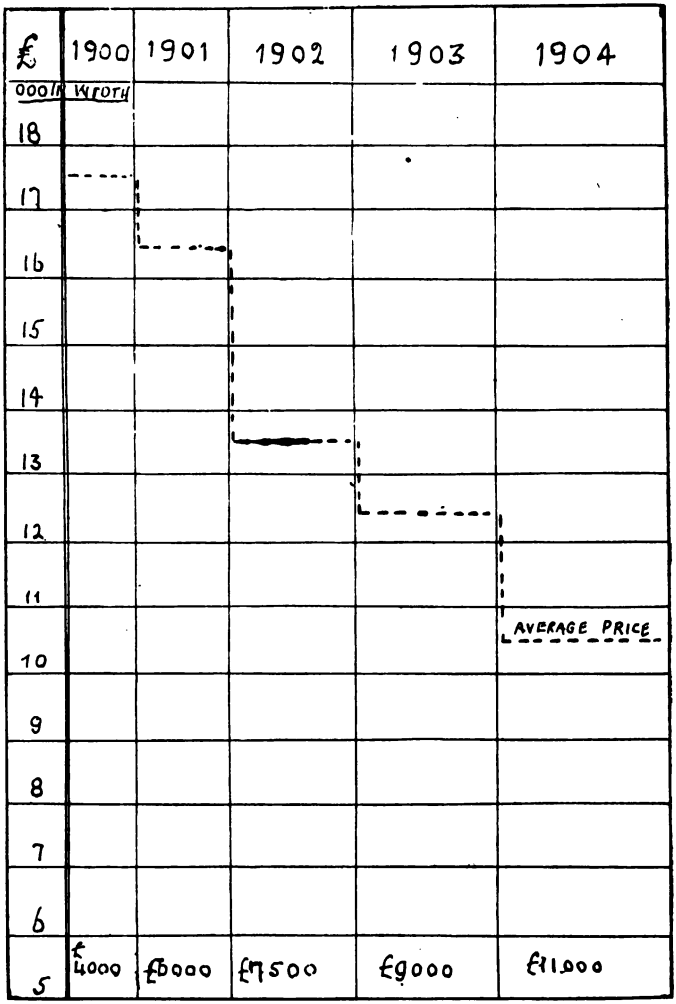
The adoption of a weekly unit of expression depends on the nature of the output. If this period is one in which the output resolves itself by reason of wages, process, or otherwise in finality, then its selection is sound.

We may here usefully consider the point of a business in which the processes are continuous, and in which several weeks elapse between the initial and completing stages. In such a case, what is the basis of output? It may be, from market or other causes, the inwards in raw material is a fluctuating quantity. In others we may have, say, three weeks' interval between the initial and completing stages. If we obtain an initial stage output, say, of 300, 400, and 500 tons, we shall have a varying departmental output of product in various stages of completion, and in such a case how is the total weekly production to be obtained? If on the finished product, then the first three weeks of the period would either be blank, or a diminished output to compare with a full expense loading in production.

In the cost grouping section it will be found that the departmental production can, and is, estimated by its relation to the finished product, and this basis the allocation of oncost demands. Just as in multiple costs it is possible to express the whole of the production in terms of the major article, so in the case of departmental production the same rule will apply. Each department represents a part of the finished production value, and thus built up we get the total production in a form for expression in the diagram No. 6.

If we take the Product No. 2 Summary of Cost we find that we have the exact data of productive value determined for each department, based on the constituent value of the finished product at each stage.

DIAGRAM SHOWING MOVEMENT OF AVERAGE PRICES IN YEARS, AND QUANTITIES SOLD.

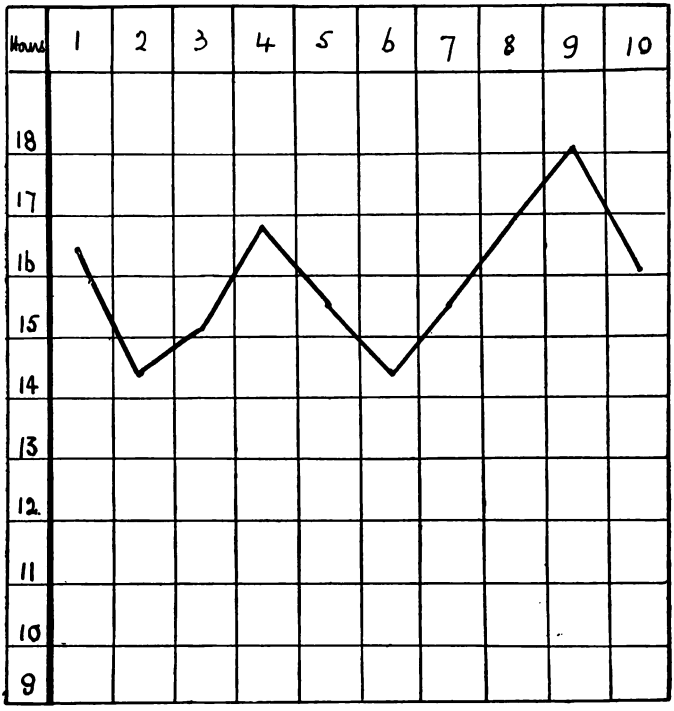


It has been suggested that, as there is no sense of relation between time and sterling, that the space division horizontally might be made variable instead of fixed, so as to denote quantity by the number of spaces included between the two vertical lines, and the foregoing diagram gives an example of

this. Incidentally this diagram represents years of fatness and years of leanness. As the step effect does not bring in any line of movement in the years there does not appear to be any objection to this form.

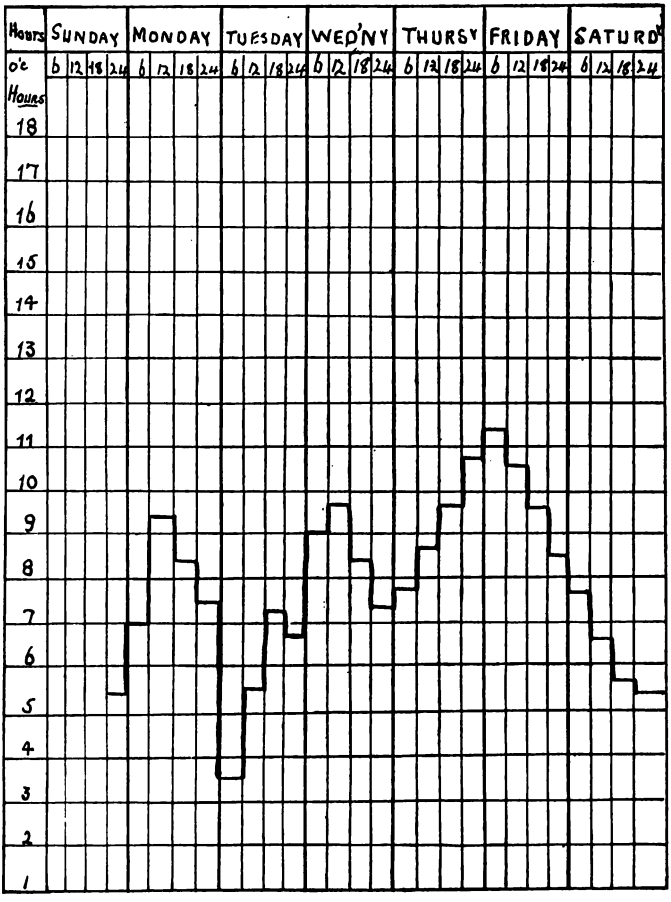
Process Control.

The advantage of diagrams in the presentment of experience in operating periods is very considerable. In the case of continuous processes any delay must of necessity act as a decrease of possible output below the maximum, and in the preparation of a standard estimate of output the experience thus obtained will be found useful in checking the apportionment of fixed charges. This chart shows the fluctuation of the period of working through one stage of process, the normal working being one of twelve hours' duration.



NORMAL LINE OF WORKING = 12 HOURS.

A further development of diagrams as applied to process control is shown by the following illustration. In this case the plant was an alternative one, and the chart shows the time in which various parts of the process plant were delayed in commencing operations, due to defects in the plant immediately preceding it in operating.



The day is divided into four periods of six hours each, and the fluctuation shown is the delay in starting which was experienced in each process commencing in the six-hour periods. The line of movement shown discloses that from the commencement of the week there was a steady loss in time going on, which increased up to Thursday, and that a recovery took place on Thursday, which was continued through Friday and Saturday on the removal of the cause of detention. As a striking epitome of working experience the appreciation here shown is considerably in advance of any appreciation which could be induced by the statement of these facts in figures.

It is also possible, by taking a continuous hourly chart for the whole of the working hours per week, to show the actual operating time of continuous processes, and by this means to indicate at a glance those departments which are at fault daily as the work is proceeding.

There is perhaps no department of commerce in which diagrams can be used to such practical effect as in process control, and consequently process costing, and the trouble and time expended is rewarded to much greater extent than would at first sight appear possible. The Card Systems may, and do, provide records, but these require both time and close attention to appreciate, while diagrams of shop and output movement, once designed, can be readily kept in touch with actual conditions, and afford at a glance the position of the operating in the stages of process which are important. It is not perhaps too much to say that, wherever a Card System can or is introduced, the expression and focussing of the results in diagram form is essential to the efficient control of the operating.

For controlling the movement of stocks, daily output, engine-hours run, and all the various items of detail which place a

factory manager in touch with the life of the works, the diagram of daily results is one of which the importance cannot well be exaggerated.

In conclusion, enough has been said to draw attention to the part which diagrams may play in the expression of experience in cost accounting, and the examples given will make it clear that, in the consideration of form, two principal factors require to be borne in mind. Firstly, that line of movement must be governed by expression of tendencies; the line must not only show the result, but show them in such a manner as to induce connection. Secondly, in dealing with completed results the fluctuations may be shown in such a manner as to make connection of experience unnecessary. The two leading examples of these divisions are to be found in Examples 1 and 10.

CHAPTER XVII.

PERIODICAL AND STATISTICAL RETURNS.

THE degree to which periodical returns and the machinery for their production can be provided depends largely on the special circumstances of the business, and the inherent fluctuations experienced in dealing with products.

In the volume on multiple costs this subject has been treated from the view of the special set of businesses included in that group, but the factors of experience in the case of process costs differ widely in relation to the utility and cost of the necessary data.

It is always understood that the provision of the necessary returns required by Parliament, and the necessity for Ministers being able at short notice to answer questions, is responsible for a considerable addition to the expense of operating the financial departments of our Treasury and subsidiary departments. In the case of our railways, the elaboration of returns is responsible for a considerable addition to the clerical work involved, and this burden is borne by all and every grade of service, from the tabulation of the weight of coal consumed by the locomotive to the train report of the guard, and the goods agent's monthly summary of traffic and comparisons of tonnage and classification.

From these elaborate systems to the trader who is content with the weekly bank balance there exists a variety of circumstances which it is impossible to classify within the space of this chapter,

but there are certain fundamental conditions of all requirements which it may be of service to note.

Firstly, all cost systems and methods necessarily imply the expression of the results obtained in some form of periodical return, and the commercial accounts should form no exception to this rule.

Secondly, if the basis of the whole business is the attainment of a certain standard estimate, then the expression of intermediate results should necessarily exhibit the experience foreshadowed by that estimate, and the divisions therein set out should form the general foundation of the periodical return.

Thirdly, the subject of periodical returns is closely associated with that of diagrams and charts, although the latter may be more properly regarded as complementary to the actual data in figures.

Lastly, all periodic statements inherently increase in value in proportion to the shortness of the period between their conclusion and publication. "He gives twice who gives quickly" is the motto which should be inscribed on the foundation-stone of all methods and systems of periodic accounting. A weekly return which is available on Monday is worth double that on Wednesday.

A further important matter in considering the provision of periodical returns is the adoption of a form which shall give in gradually decreasing focus the details. If there is to be a provision for the board of directors, then the same form should expand for the management and expand again for departmental responsibility. Our form should be like a tree, the higher you go the more minute the subdivision, yet all branches converge in the trunk.

In the Cost Grouping, Section No. 2, we have forms of Weekly Returns which are cumulative in effect, and the further carrying into effect of these on the same system for the commercial accounts, embraces all the points of interest in the expression of the experience of the undertaking.

The provision of returns depends primarily on the efficiency of the staff for their production. Apart from their own value, there can be no finer method of compulsion for the maintenance of the bookkeeping thoroughly up to date, and the avoidance of disputed and indefinite records. If only for this reason, the provision of an efficient form of Weekly or Periodical Return is to be commended. After the trouble of their initiation is once over they will be found of little trouble, and a return properly designed and correlated to the totals available from the weekly totals of the Day Books, Purchase Books, and expenses postings and factory returns, should be compiled in half-an-hour.

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